BBC THE ANIMALS WHOSE LIVES RELY ON THE NIGHT SKY

#240 MAY 2025

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

ARE WE ALONE?

Alien-hunting experts reveal why we're closer than ever to discovering life among the stars

PLUS The Red Planet meets the Beehive Cluster

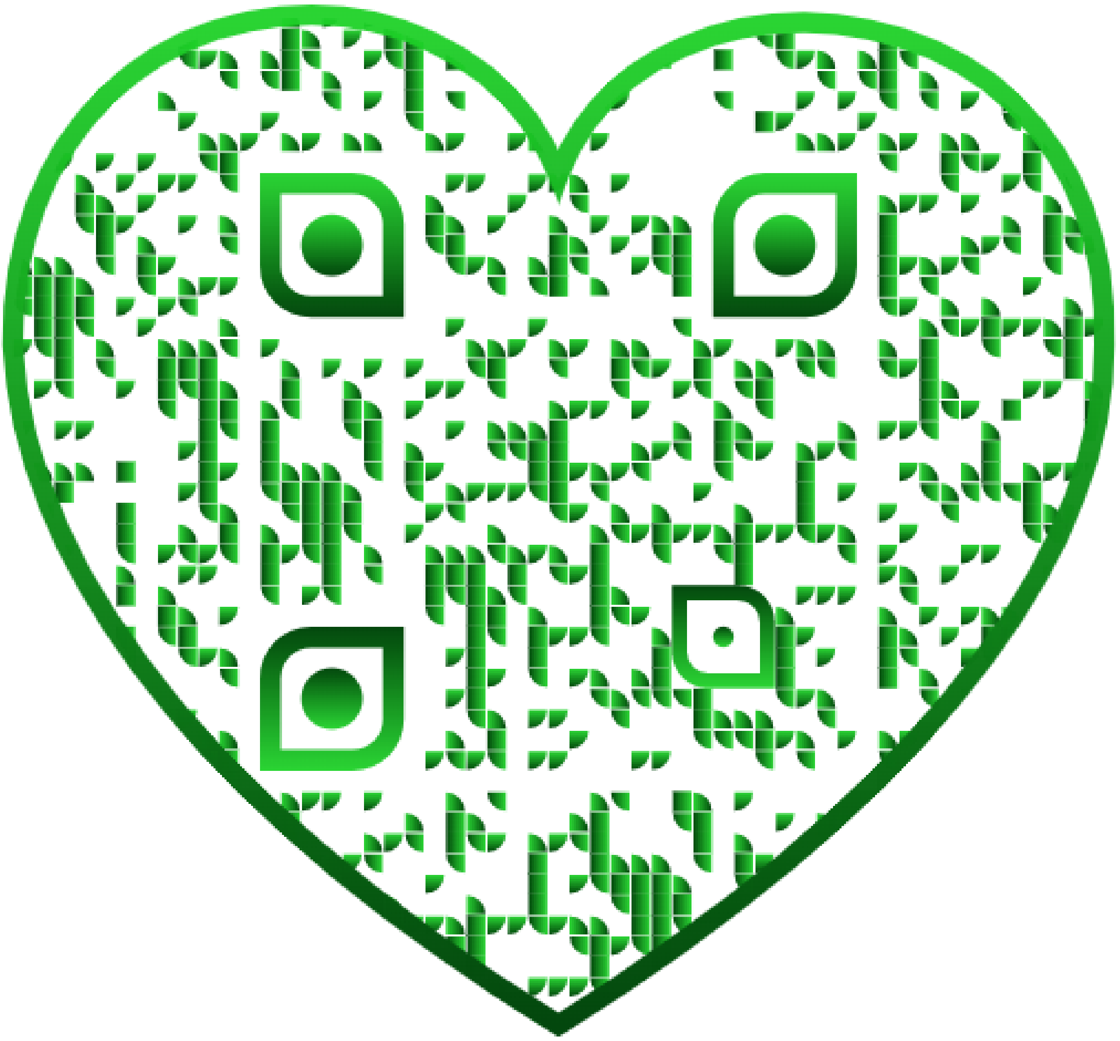
THE EUROPEAN SPACE AGENCY: 50 YEARS OF EXPLORATION

CHINA'S MISSION TO BRING ASTEROID SAMPLES TO EARTH

PORTABLE PLATFORM: NEW SKY-WATCHER MOUNT TESTED

HOW ALIENS WILL DETECT OUR TECH FROM SPACE

THE REAL ZODIAC: THE STARS BEHIND THE STAR SIGNS



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Welcome

Are we the only example of life among all those suns?

Looking up at the stars on a clear night, there's one question that often springs to mind: are we alone? So we asked four expert astronomers involved in the search for extraterrestrial life what they thought. Each approaches the question from a different angle, but their answers are the same in these respects: they are all equally fascinating, thought-provoking and optimistic about the quest. Turn to our feature on **page 60** to read what they said.

Through missions like Juice and Mars Express, the European Space Agency is actively involved in the search for life elsewhere in space. This month, Europe's space agency marks 50 years since its formation. We look back on five decades of space exploration on **page 34**, selecting highlights that reflect its broad mission, including the remarkable comet-chasing mission Rosetta.

There's another mission launching this month to investigate the small bodies of the Solar System, China's Tianwen-2. Our feature on **page 28** follows the probe's flight schedule to not one but two asteroids. Its first rendezvous, with asteroid Kamoʻoalewa, comes in 2026, when it will retrieve samples and return them to Earth before setting off once again to meet 311P/PanSTARRS.

And speaking of asteroids, May sees the brightest asteroid visible from Earth, Vesta, reach maximum brightness as it moves into opposition. Do take the chance to seek it out with binoculars, using the observing details in our Sky Guide on **page 47**.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 20 May.

HOW TO CONTACT US

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Sky at Night – lots of ways to enjoy the night sky...

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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Visit our website for space news, astrophoto galleries, observing guides and more

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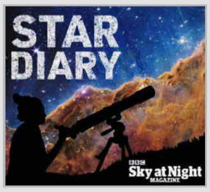

Podcasts

Discover the best things to see in the night sky every week by listening to our Star Diary podcast

Sky at Night
GALAXY SEASON

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Get each month's issue on your Apple or Android device, now with bonus image galleries

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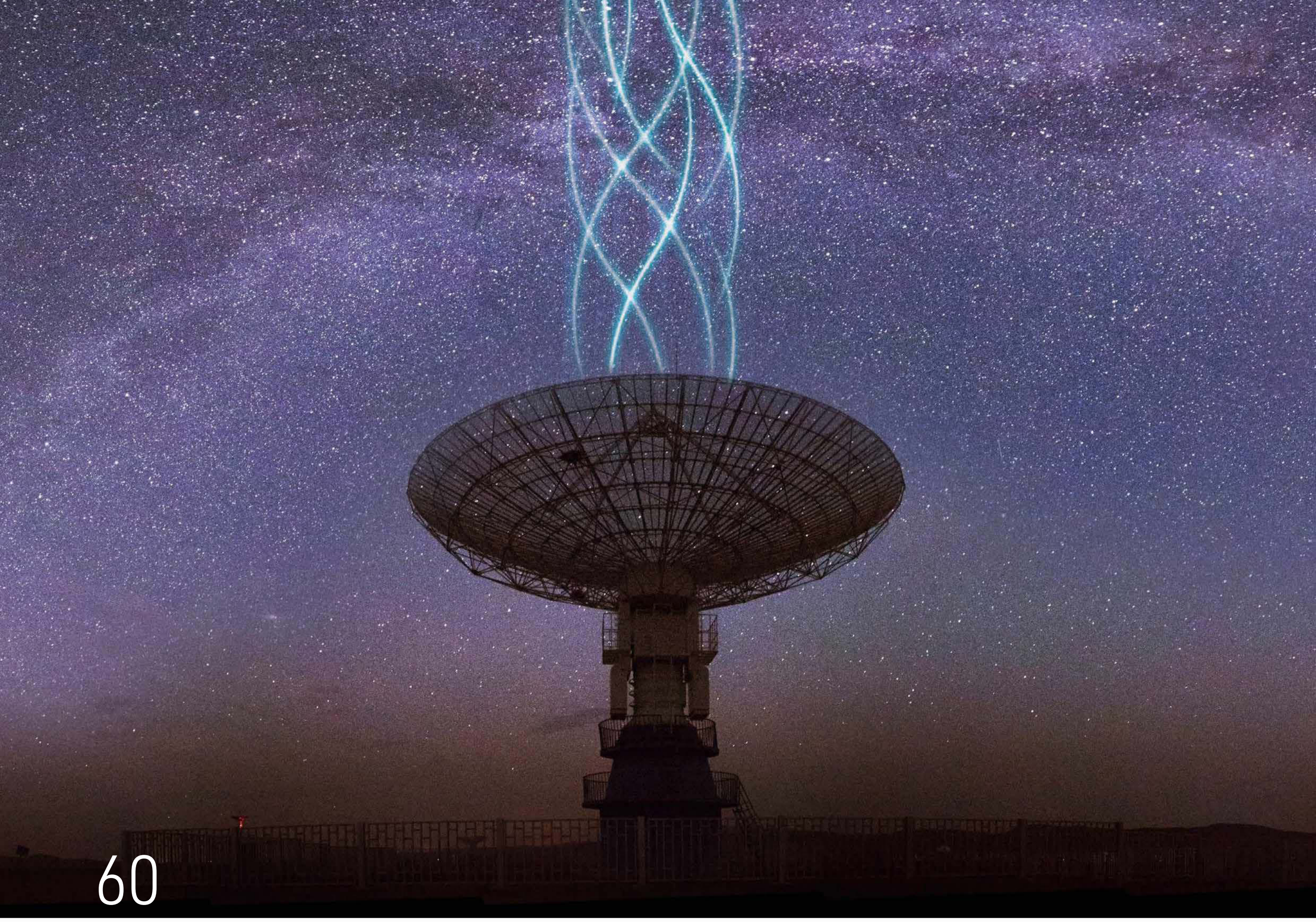
The best targets to observe each week, delivered to your inbox. Visit **bit.ly/skynewsletter**

Find out more at: www.skyatnightmagazine.com



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The real zodiac, explained

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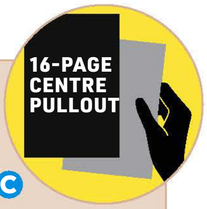

The Sky Guide

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

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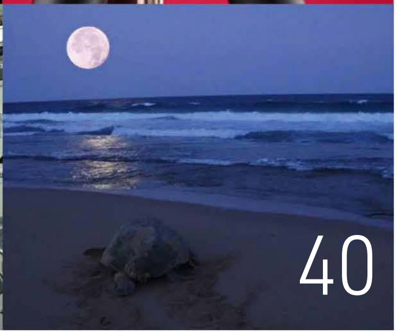
WAVE 100i
WiFi



This month's contributors

Anita Chandran

Science journalist

"In the run-up to ESA's 50th anniversary, it's been great to look at its achievements and future ambitions, cementing its place at the forefront of space science." **Read the story of the European Space Agency on page 34**

Franck Marchis

SETI scientist

"Humanity searches for life in the Universe to satisfy our deep desire to connect with beings similar to ourselves – a connection that offers hope for our future as a species." **Discover how experts like Franck hunt alien life, page 60**

Mary McIntyre

Astronomy teacher

"There's more to the zodiac than 'star signs'. In this issue, we're taking a year-long tour through the zodiacal constellations to see what jewels lie within." **Read Mary's guide to the real zodiac on page 66**

FREE BONUS CONTENT

Find it at **www.skyatnightmagazine.com/bonus-content**

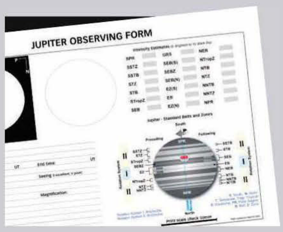
MAY HIGHLIGHTS

Strange signals from the 'Eye of God'

Astronomer Martin Guerrero discusses the X-ray signals that could indicate a planet torn apart by a dying star.

Binocular and deep-sky tours

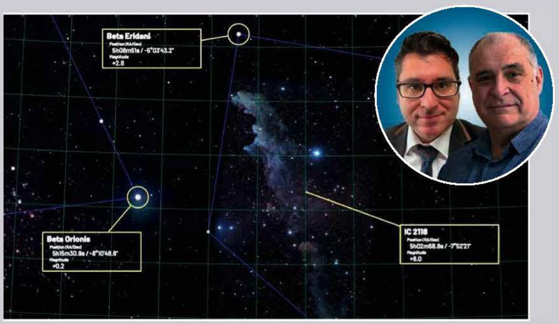
Download and print off charts to help you find some of the best deep-sky targets listed in this month's Sky Guide.



Planet and solar observing forms

Become a citizen scientist and keep records of your observations of the Sun and the planets.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

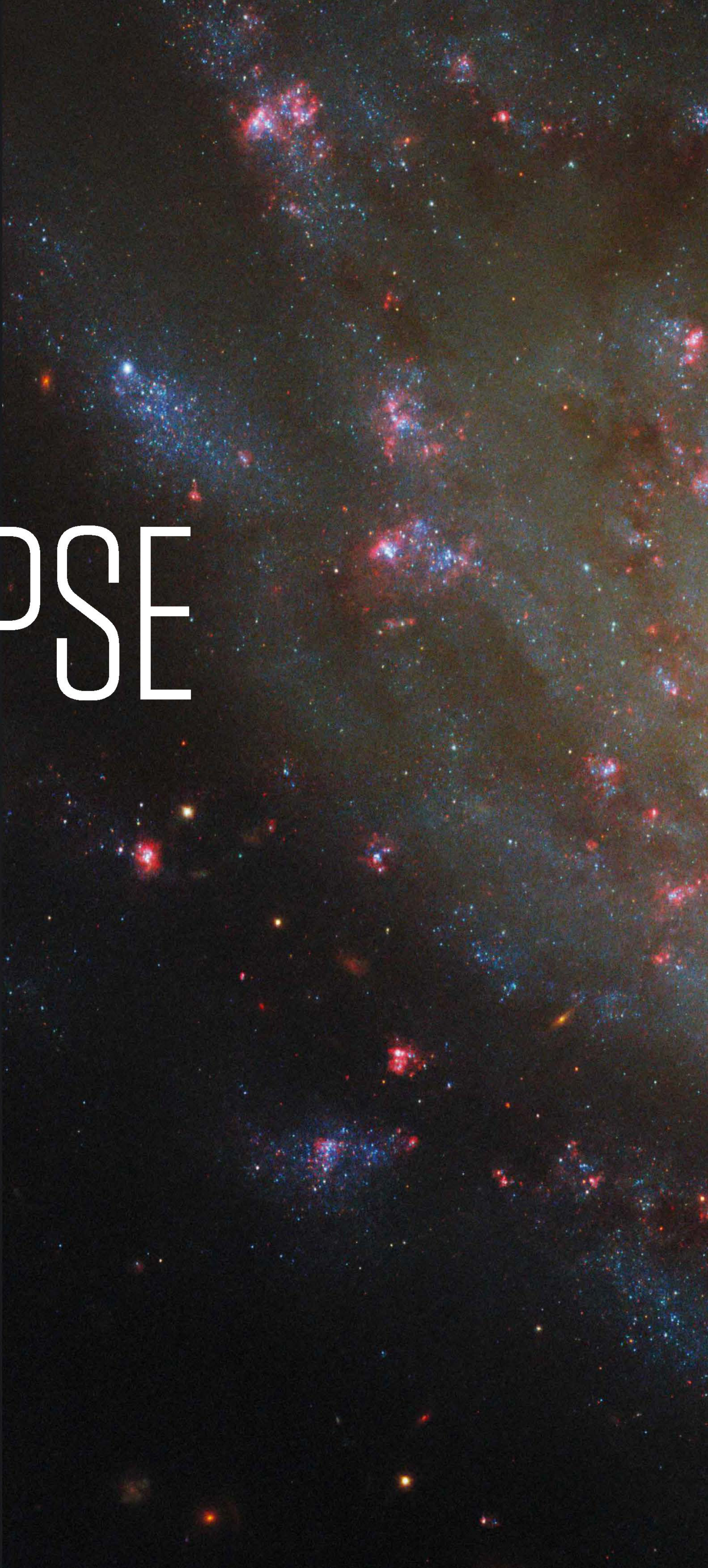
A FLEETING GLIMPSE

Gas clouds briefly glow pink, thanks to blasts from this galaxy's live-fast-die-young blue stars

HUBBLE SPACE TELESCOPE, 3 MARCH 2025

Seen here is NGC 5042, an intermediate spiral galaxy lying some 48 million lightyears from Earth in Hydra. It reveals a creamy-coloured core full of ancient stars, while its spiral arms are home to many young, blue stars. Distant galaxies beyond can be seen as yellow and orange blobs.

Take a look at the pinkish areas. These are HII regions, vast clouds of hydrogen ionised by ultraviolet light streaming from those hot, massive, blue stars. Those stars won't live long, though, meaning the HII regions themselves will only be around for a few million years. In the context of the Universe, that's just the blink of an eye.



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Explore a gallery of these and more stunning space images
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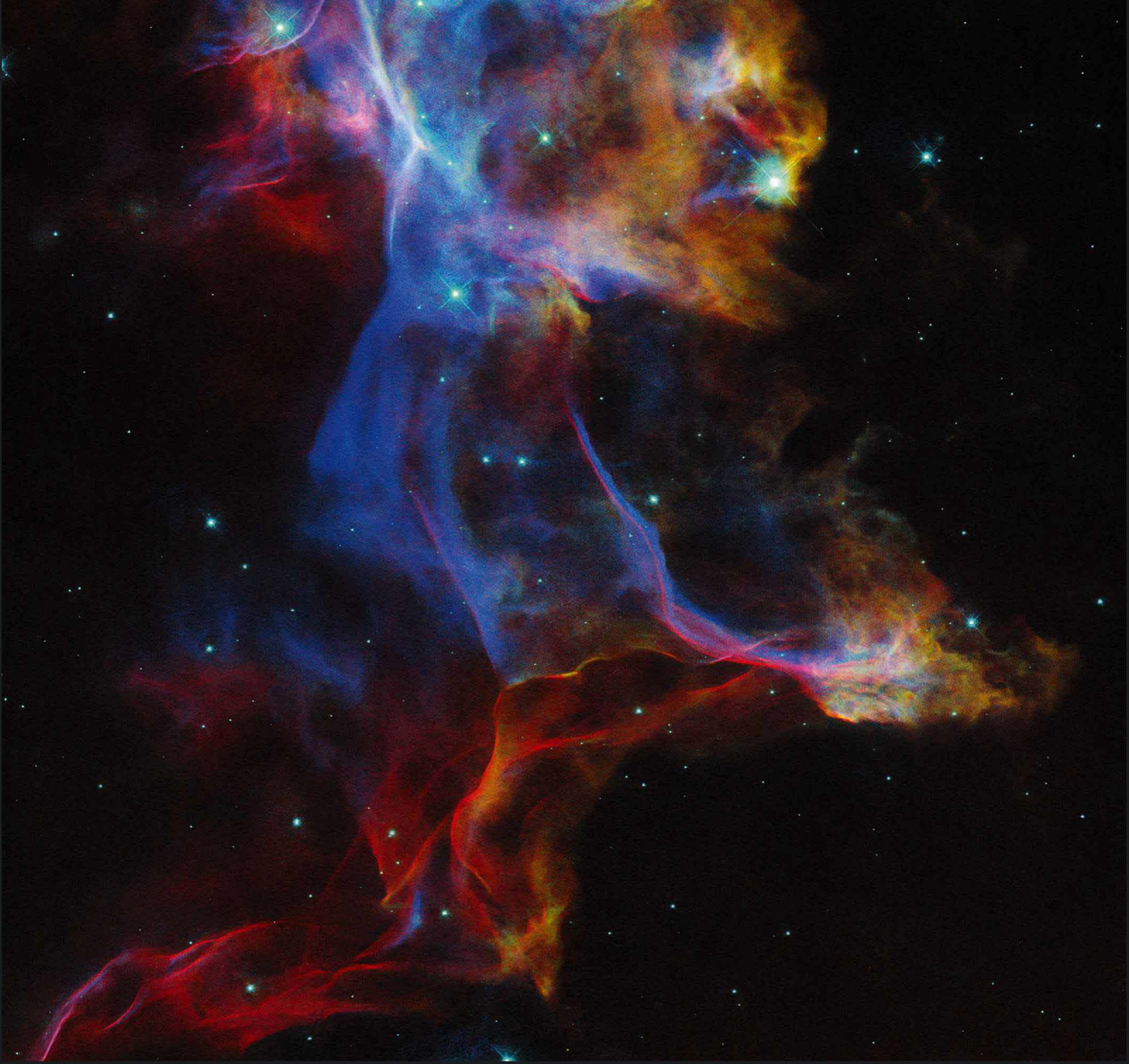


△ Lifting the veil

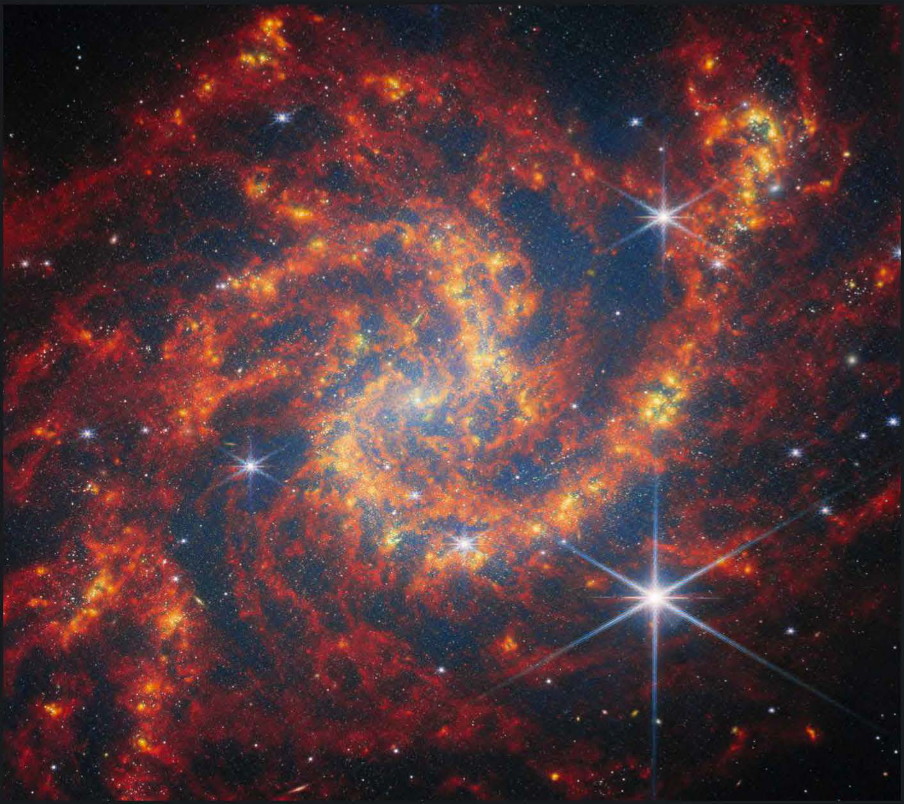
HUBBLE SPACE TELESCOPE, 24 FEBRUARY 2025

The Veil Nebula is all that's left of a star 20 times more massive than our Sun that exploded 10,000 years ago. This image showing part of it is Hubble's first shot of the famous supernova remnant since 2015. Astronomers will now compare this image with Hubble's previous observations to learn more about the nebula's evolution.

17-minute wonder ▷

JAMES WEBB SPACE TELESCOPE, 28 FEBRUARY 2025

What can you achieve in 17 minutes? Read a few pages? Make a snack? For JWST, it was enough time to gather the data to create this image of barred spiral galaxy NGC 2283, a region of star formation in the constellation of Canis Major. From that brief window, Webb's infrared vision revealed the galaxy's stars and glowing hydrogen gas, 45 million lightyears away.

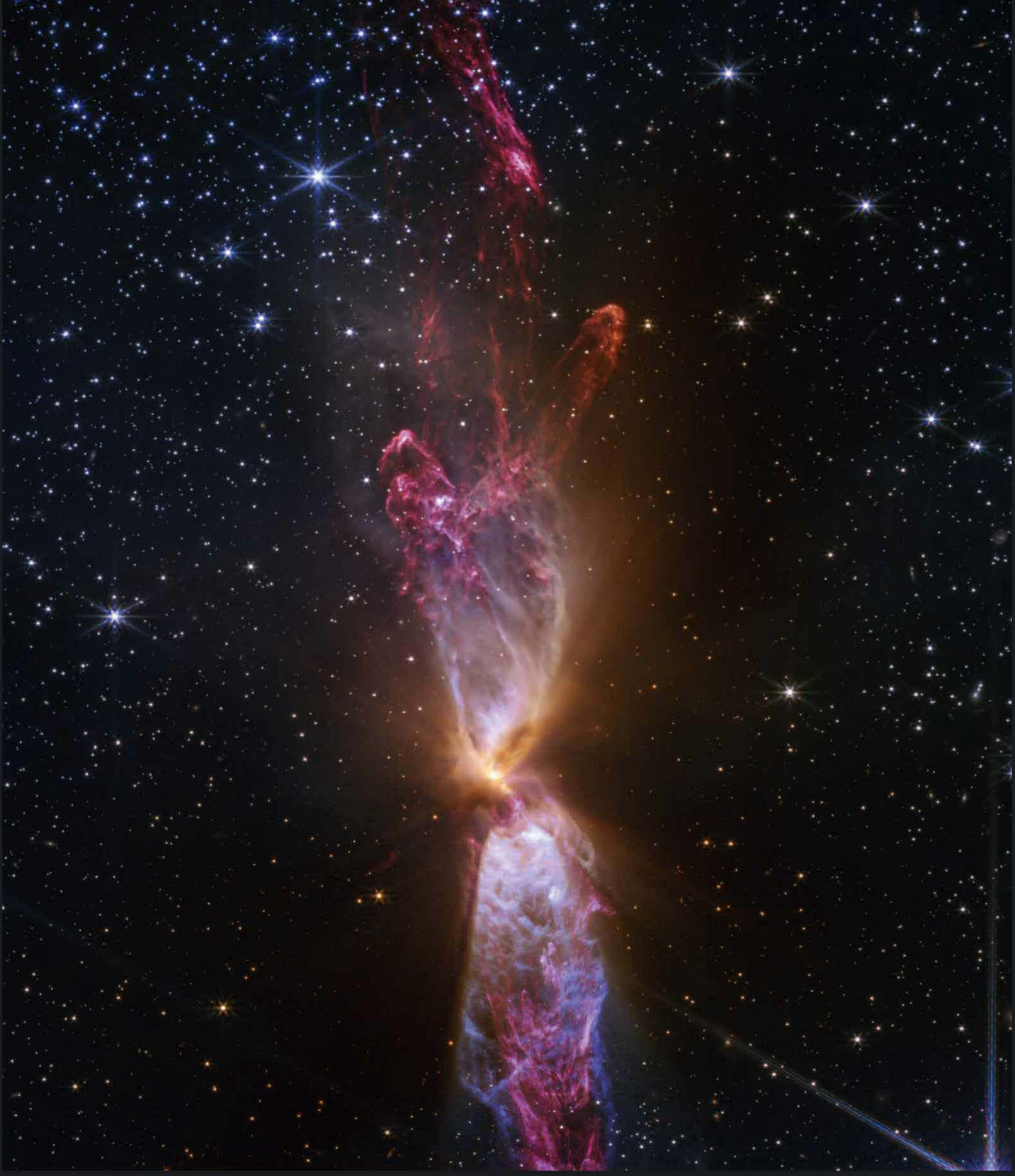


ESA/HUBBLE & NASA/R. SANKRIT, ESA/WEBB/NASA & CSA/A. LEROY, NASA/ESA/CSA/STSCI, ESA/EUCLID/EUCLID CONSORTIUM/NASA/IMAGE PROCESSING BY M. WALMSLEY/M. HUERTAS-COMPANY/J.-C. CUILLANDRE

Here today, gone tomorrow ▷

JAMES WEBB SPACE TELESCOPE, 7 MARCH 2025

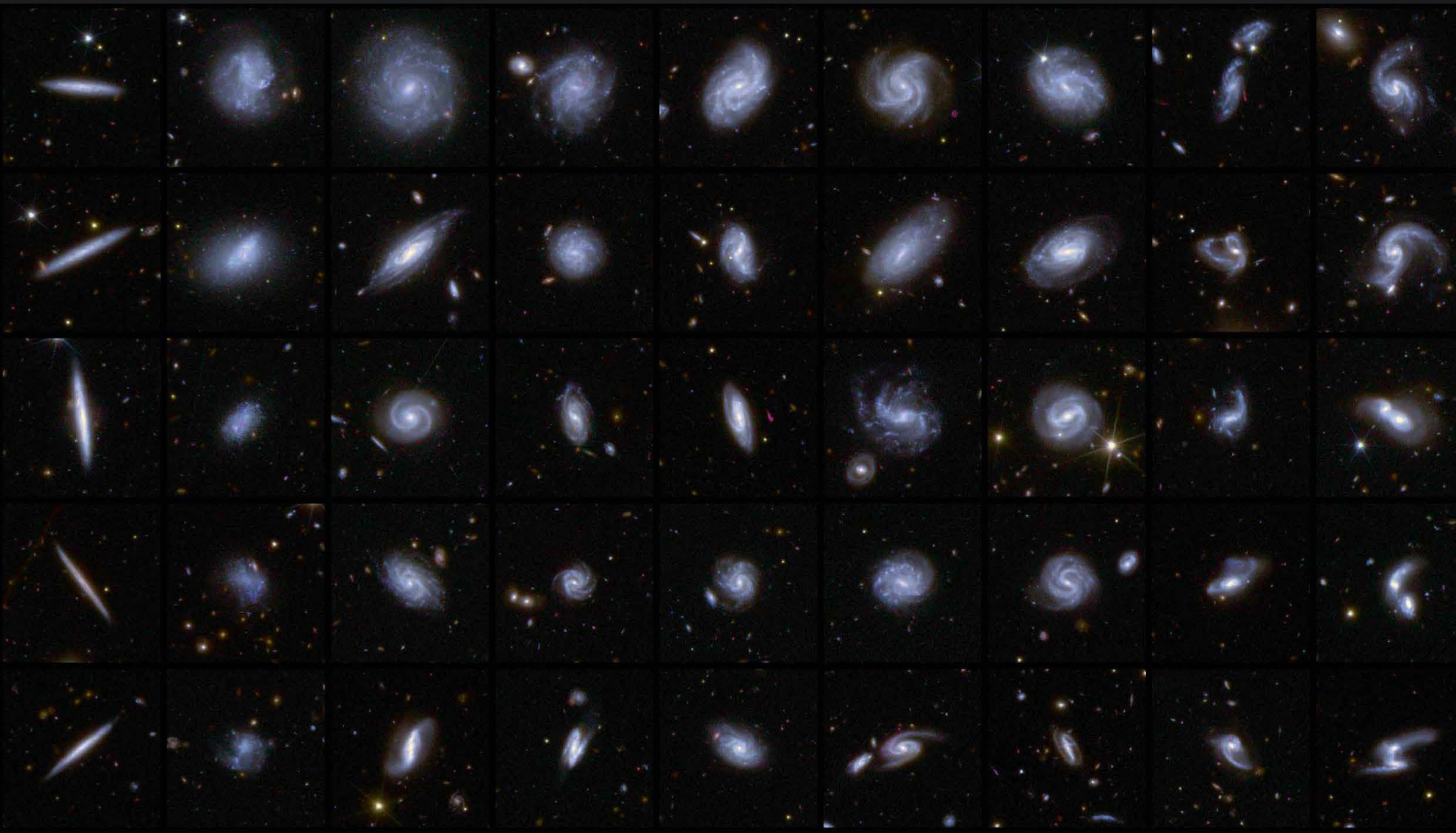
Lynds 483 is a short-lived object that's been around for less than 100,000 years and will vanish in less than a million. The two jets that seem to form an hourglass shape are outflows of gas from two nascent central stars. As the newborn stars grow, these outflows will diminish and eventually disappear.



▽ Galaxies galore

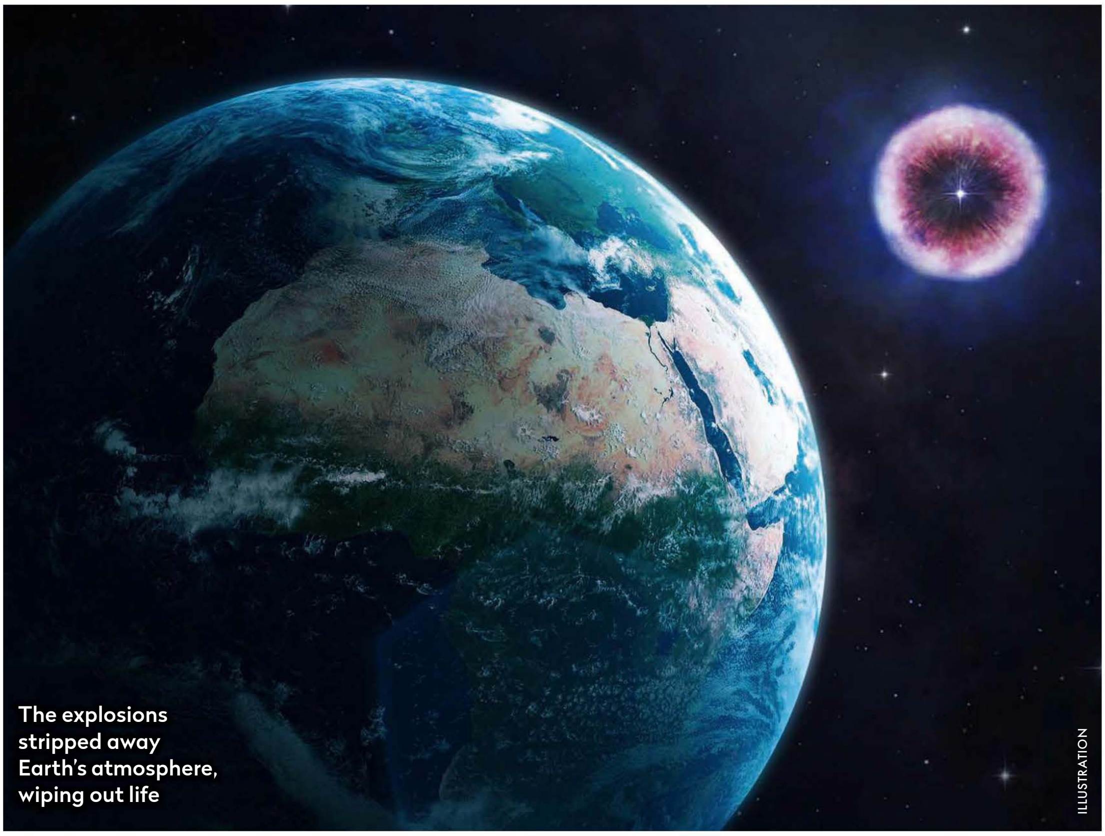
EUCLID, 19 MARCH 2025

Spiral galaxies are like fingerprints: they all look roughly similar but no two are exactly alike. This collage is part of the first batch of survey data released from ESA's Euclid space telescope and includes edge-on galaxies, face-on spirals and, on the right, pairs of galaxies colliding.



The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



The explosions stripped away Earth's atmosphere, wiping out life

Killer supernovae devastated life on Earth – twice

Nearby star deaths may have caused two of our planet's mass extinctions

Exploding stars could have been responsible for ravaging our planet's atmosphere and causing two mass extinctions. The discovery comes from a recent survey of local stars, which aimed to measure how often supernovae happen in the vicinity of Earth.

A supernova occurs when a massive star runs out of fuel at the end of its life and collapses before rebounding in a huge explosion that fires out radiation and stellar material in all directions.

"Supernova explosions bring heavy chemical elements into the interstellar medium, which are then used to form new stars and planets," says Alexis Quintana, who led the study while at Keele University. "But if a planet, including Earth, is located too close to this kind of event, this can have devastating effects."

If a supernova's radiation were to sweep over Earth at close range, it could strip our planet's ozone layer. This would leave life vulnerable to ultraviolet radiation from the Sun, as well as causing years of acid rain. To see if this might have happened to our planet in the past, Quintana's team looked at a census of massive stars within 3,260 lightyears of Earth. They used this data to estimate how often supernovae occur close enough to have an impact on Earth's atmosphere, out to around 65 lightyears from our planet.

This revealed there should be around 2.5 nearby supernovae every billion years, a rate which tallies with the number of extinction events seen here on Earth: the Devonian extinction 372 million years ago and the Ordovician extinction 445 million years ago. These two events have been linked to a loss of ozone, though the cause of the sudden change was unknown.

Fortunately for us, only two nearby stars look set to go supernova in the next few million years: Betelgeuse and Antares. Both of these are more than 500 lightyears away, a safe enough distance from our planet's fragile atmosphere.

www.keele.ac.uk

NASA/CXC/M. WEISS/GETTY, NASA'S GODDARD SPACE FLIGHT CENTER, NASA

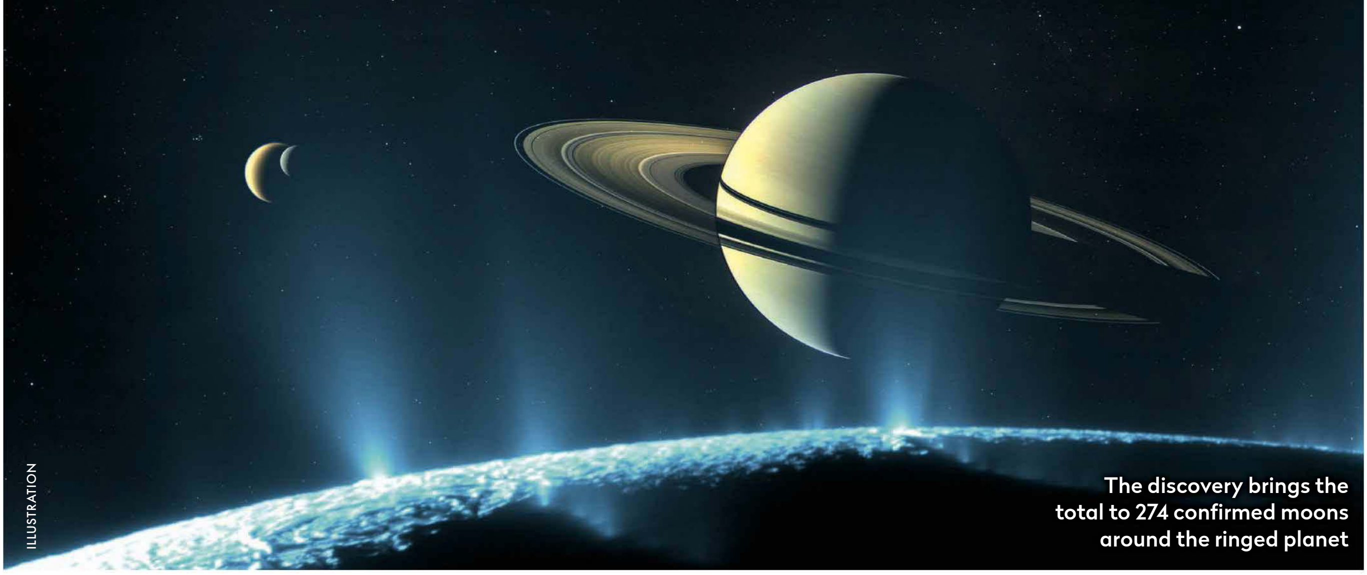
Comment

by Chris Lintott

Why are we so drawn to the idea of catastrophe coming from the skies? The imminent death of Betelgeuse, the threat from asteroids like 2024YR4, and past extinctions and exploding stars undoubtedly have a morbid fascination.

But I'll remind you that a nearby supernova may have kickstarted the formation of the Sun and its retinue of planets. The Ordovician extinction may have created the conditions for a grand explosion in ecological diversity. Even the asteroid that did for the dinosaurs was good news for us mammals. Earth's history and our own can only be properly understood once we pay attention to what's happening in our cosmic neighbourhood, good or bad.

Chris Lintott co-presents *The Sky at Night*



The discovery brings the total to 274 confirmed moons around the ringed planet

Saturn gains 128 new moons

The moons have probably only existed for 100 million years

Saturn unequivocally tops the charts as the Solar System's moon collector after 128 new satellites were discovered around the planet. This brings its total moon count to 274, more than the rest of the Solar System combined.

The gas giant previously gained 64 new moons following an observing run by the Canada–France–Hawaii Telescope between 2019 and 2021.

"With the knowledge that these were probably moons, and that there were likely even more waiting to be discovered, we revisited the same sky fields for three consecutive months in 2023," said Edward Ashton, who conducted the study while at the University of British Columbia, Canada. "Sure enough, we found 128 new moons. Based on our projections, I don't think Jupiter will ever catch up."

Like the other gas giants, it's thought that Saturn gathered most of its moons by capturing passing asteroids not long after the Solar System formed 4.5 billion years ago. However, it was probably a more recent event that led to Saturn having so many. All the new satellites are only a few kilometres in size, irregularly shaped and in a similar orbit near what's called the Mundilfari subgroup, named after one of the larger moons within it. This suggests the moons were once a larger body that broke apart, most likely when it collided with another moon or comet. The resulting fragments in turn collided with each other and ground themselves away over time. The fact there are so many means the impact must have occurred in the last 100 million years.

There may be even more Saturn moons waiting to be found, but it could take some time to discover them.

"With current technology, I don't think we can do much better than what has already been done for moons around Saturn, Uranus and Neptune," says Ashton. **www.phas.ubc.ca**

NASA fires chief scientist

The move could signal a shift from science to exploration

NASA has dismissed its chief scientist to comply with orders from President Trump, it was announced on 11 March.

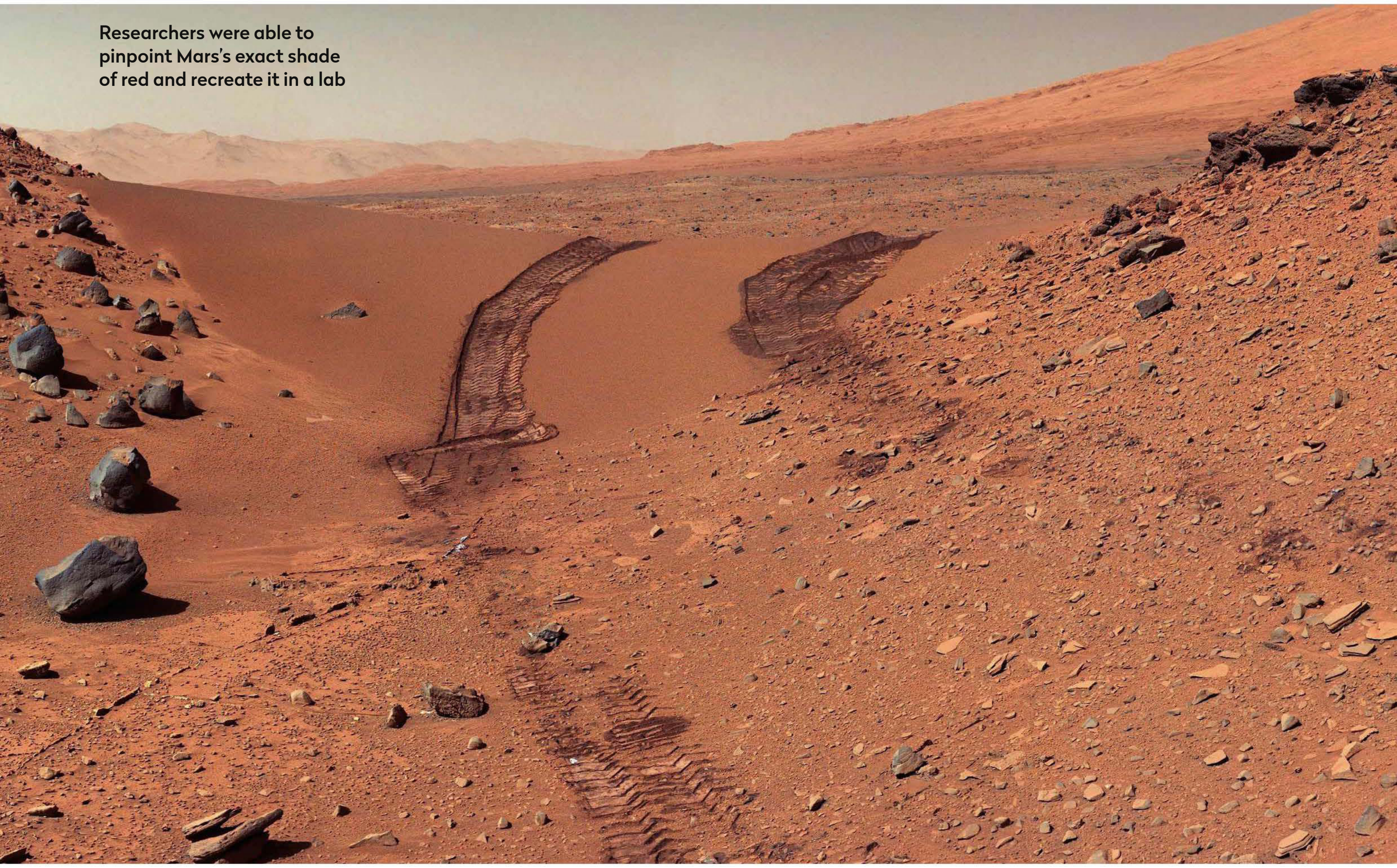
The order removed the Office of the Chief Scientist, a post held by Dr Katherine Calvin, who also served as the agency's senior adviser on climate. Trump has referred to climate change as "a scam" and made other moves to stop federally funded climate research, including pulling the US out of the Paris Agreement for a second time and dismissing hundreds of employees from the National Oceanic and Atmospheric Administration (NOAA).

The move may also signal an intention to shift NASA away from scientific research to exploration, as Trump indicated in a speech to a joint session of Congress on 4 March, where he said the US would "plant the American flag on the planet Mars and even far beyond".

The order also removed NASA's Office of Technology, Policy and Strategy, as well as the Diversity, Equity, Inclusion and Accessibility branch in the Office of Diversity and Equal Opportunity. While the cuts only affected 23 people, a memo from acting administrator Janet Petro indicated more may follow.

Chief scientist Katherine Calvin's position at NASA has been eliminated

"We are actively working with the US Office of Personnel Management (OPM) to develop a thoughtful approach that aligns with both administration priorities and our mission needs," it stated. "While this will mean making difficult adjustments, we're viewing this as an opportunity to reshape our workforce, ensuring we are doing what is statutorily required of us while also providing American citizens with an efficient and effective agency." **www.nasa.gov**



Researchers were able to pinpoint Mars's exact shade of red and recreate it in a lab

NASA/JPL-CALTECH, KEEGAN BARBER/NASA VIA GETTY IMAGE X 3

Study uncovers why the Red Planet is red

Mars may have taken on its rusty colour when oceans still covered the planet's surface

The colour of Mars's surface is so iconic that it's often simply referred to as the Red Planet. Now a new study has shown it might have taken on this distinctive hue much earlier in its history than previously thought. Though Mars is now bone dry, it appears the colour developed when the planet was still covered with water.

Mars's red colouration has been known about since ancient times as it is clearly visible from Earth, even to the naked eye. The cause of its distinctive colour, however, was only discovered when the first spacecraft arrived at the planet in the 1960s and '70s. These pointed towards iron minerals which had become oxidised, or rusted. Over billions of years, these iron-rich rocks were ground down, coating the planet in its famous red dust.

What wasn't so obvious was exactly which mineral was responsible. Previous studies from orbital observations found no traces of water within the dust. Geologists concluded this must mean the mineral was hematite, which forms under dry conditions. As Mars was covered in liquid water for its first billion years or so, this would mean it only reddened after the planet had dried out.

The new study looked at observations not only from ESA's Trace Gas Orbiter and NASA's Mars Reconnaissance Orbiter, but data from ground-based craft such as NASA's Martian rovers, Curiosity and Opportunity. Using these, the team were able to pinpoint the exact shade of Mars's red surface. They then attempted to recreate this colour in a lab to find which cocktail of minerals would create the Red Planet's dust.

"We found that ferrihydrite mixed with basalt, a volcanic rock, best fits the minerals seen by spacecraft at Mars," says Adomas Valantinas from Brown University, who led the study.

Ferrihydrite forms in the presence of cool water, meaning it must have formed when liquid water was present on Mars's surface. This means the ferrihydrite must have formed much earlier than previously thought, before the water disappeared. As ferrihydrite is stable, it would have stayed the same colour even after this happened.

"Mars is still the Red Planet. It's just that our understanding of *why* Mars is red has been transformed," says Valantinas.
www.esa.int

Earth welcomes ‘stranded’ space duo

The pair unexpectedly spent nine months longer than intended on the ISS

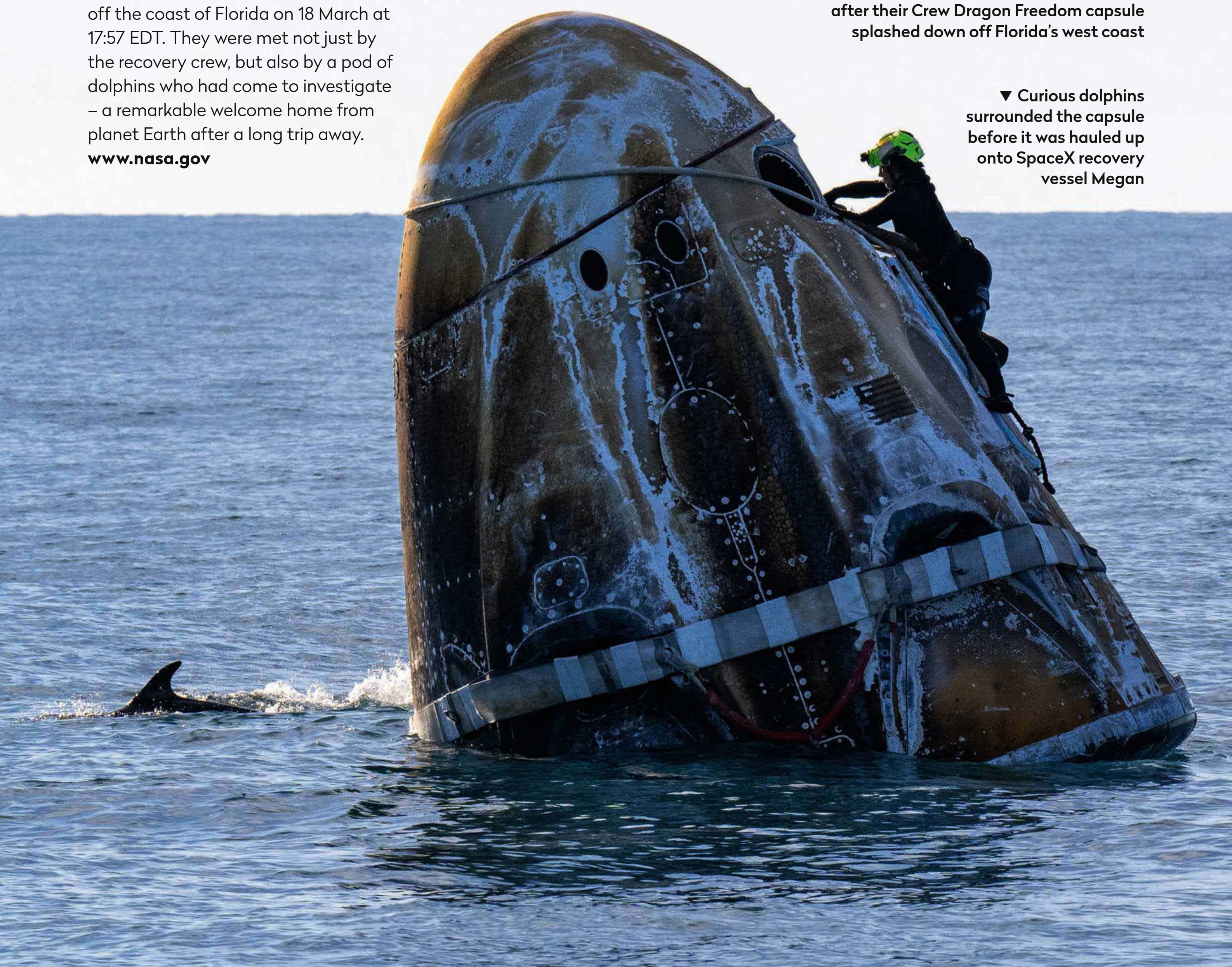
Astronauts Suni Williams and Butch Wilmore have finally returned to Earth after their eight-day visit to the International Space Station turned into a nine-month stay.

The pair of veteran astronauts arrived at the ISS in June 2024 while conducting the first test crewed flight of Boeing’s Starliner spacecraft. The original plan was to return on the same vehicle, but thruster problems meant it was unsafe to do so. While the pair could have returned to Earth on another spacecraft before now if there had been an emergency, NASA decided it would be less disruptive to simply integrate them into the ISS’s crew until they could reshuffle the astronaut rotation to allow them to come home.

They returned to Earth on a SpaceX Crew Dragon capsule, splashing down just off the coast of Florida on 18 March at 17:57 EDT. They were met not just by the recovery crew, but also by a pod of dolphins who had come to investigate – a remarkable welcome home from planet Earth after a long trip away.

www.nasa.gov

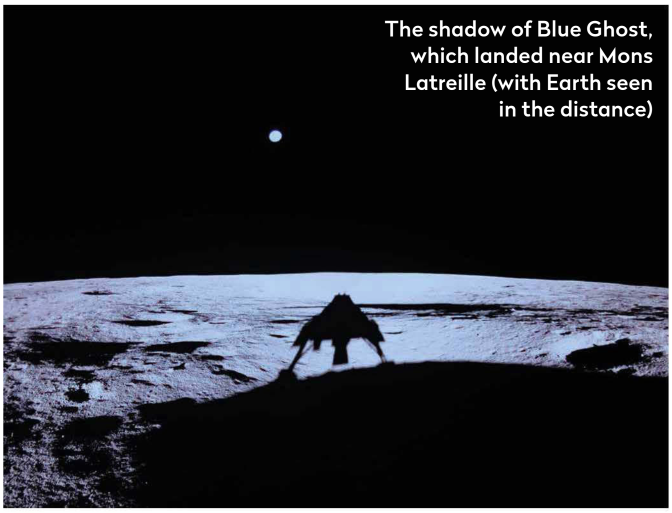
▲ Both astronauts were in good spirits after their Crew Dragon Freedom capsule splashed down off Florida’s west coast



▼ Curious dolphins surrounded the capsule before it was hauled up onto SpaceX recovery vessel Megan

March sees Moon double-landing

While one craft operated for a full mission, the other lasted only a few hours



The shadow of Blue Ghost, which landed near Mons Latreille (with Earth seen in the distance)

A pair of private lunar landers arrived on the Moon's surface this March, though only one managed to stick the landing.

The Blue Ghost lander from Firefly Aerospace touched down in Mare Crisium on 2 March at 07:34 GMT. The lander was carrying 10 NASA experiments as part of the agency's Commercial Lunar Payload Services (CLPS) initiative, which uses private companies to support its lunar ambitions. Blue Ghost operated for a full lunar day (around 14 Earth days), but wasn't designed to survive the long, dark night.

"The science and technology we send to the Moon now helps prepare the way for future NASA exploration and long-term human presence to inspire the world for generations to come," says Nicky Fox, associate administrator for science at NASA. "We're sending these payloads by working with American companies – which supports a growing lunar economy."

A few days later, on 6 March, the Athena lander from Intuitive Machines touched down at the lunar South Pole at 17:30 GMT. Unfortunately, it soon became apparent the lander was on its side.

"With the direction of the Sun, the orientation of the solar panels and extreme cold temperatures in the crater, Intuitive Machines does not expect Athena to recharge," the company said in a statement.

The cause is unknown, but altimeters – which measure how far the spacecraft is from the ground – were providing noisy readings during the landing. The low angle of the Sun at the lunar South Pole can confuse sensors, which may have happened here. Athena was also carrying several CLPS experiments which may have been able to gather some science data, as the spacecraft managed to operate off its battery for 13 hours while on the surface.

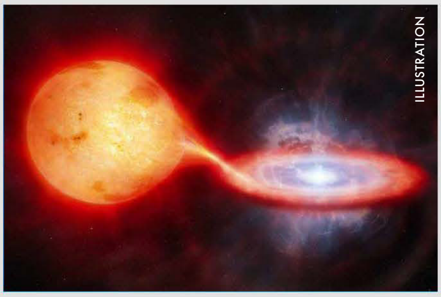
The failure of Athena will have particularly stung, as the company's previous landing attempt in February 2024 also came down on its side after a support leg broke upon landing.

The star that won't stop exploding

Every four years, the white dwarf detonates in one of the most violent ways ever seen

One of the hottest novae on record has been spotted exploding with a temperature of over 3 million °C (5.4 million °F).

Novae occur when a white dwarf steals material from a larger companion star. The gas gathers on the white dwarf until it erupts. In some cases, the dwarf star then resumes its gas theft, restarting the cycle.



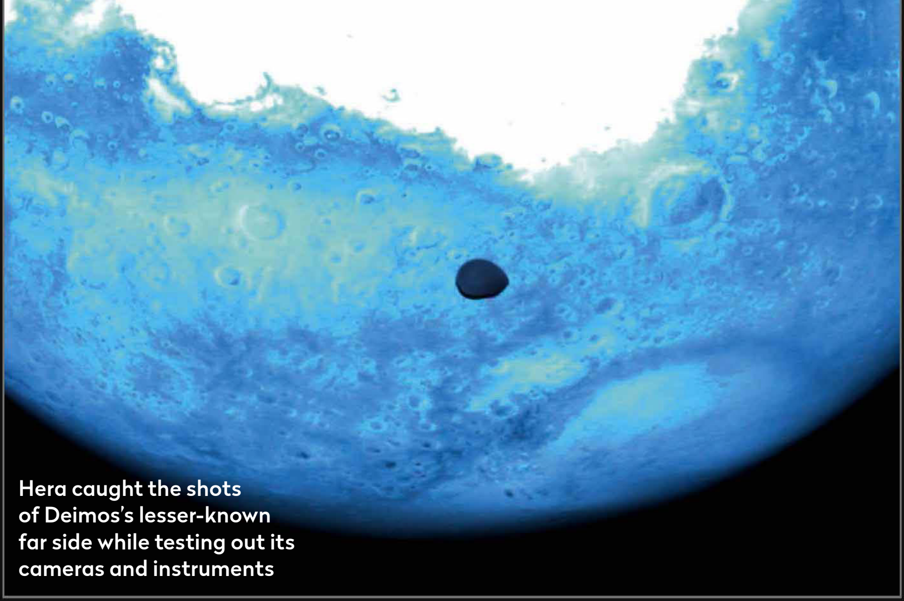
▲ **LMC86 siphons material from a nearby larger star before dramatically erupting**

As well as being one of the hottest, the object, LMC86, is the first 'recurring' nova to be seen outside our Galaxy. Located in the Large Magellanic Cloud (LMC), it erupts every four years and was extensively monitored during an explosion in August 2024. Researchers made the first-ever observations of an object at such distance using near-infrared spectroscopy, which allowed them to examine the nova's most extreme phase. This revealed highly ionised silicon, shining much brighter than the Sun's light across all wavelengths.

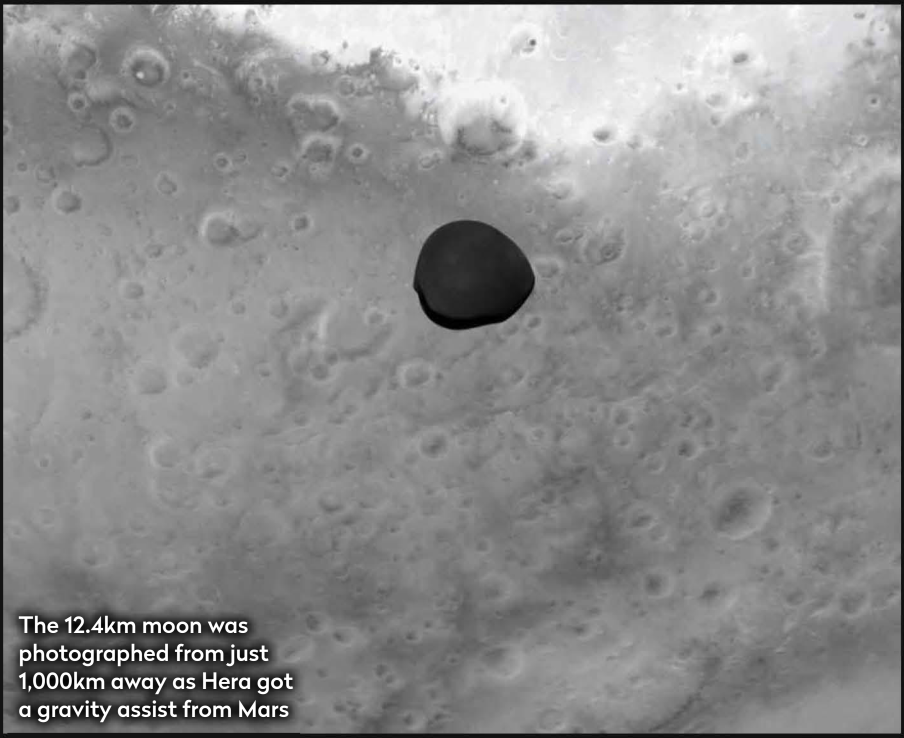
"The ionised silicon shining at almost 100 times brighter than the Sun is unprecedented," says Tom Geballe, a NOIRLab emeritus astronomer who took part in the study. Even more surprising is that silicon seems to be the only ionised element. "We would've expected to also see signatures of highly energised sulphur, phosphorus, calcium and aluminium."

This indicates unusually high temperatures, possibly due to its location in the LMC, where stars have much lower levels of heavy elements. Simulations show these would allow stellar material to accumulate for longer, meaning they would ignite with more violence. **www.noirlab.edu**

FIREFLY AEROSPACE, INTERNATIONAL GEMINI OBSERVATORY/ NOIRLAB/NSF/AURA/M. GARLICK/M. ZAMAN, ESA X 7



Hera caught the shots of Deimos's lesser-known far side while testing out its cameras and instruments



The 12.4km moon was photographed from just 1,000km away as Hera got a gravity assist from Mars

Mars's mystery moon

While testing its instruments, Hera got a rare look at Deimos

Measuring just 12.4km (7.7 miles) across, Mars's diminutive moon Deimos is often overlooked. Tidally locked to the Red Planet, it is usually missed by spacecraft near Mars that only see the side of it that's closest to the planet. However, when ESA's Hera mission came within just 1,000km (620 miles) of it, it snapped some rare pictures of the moon's 'far side'.

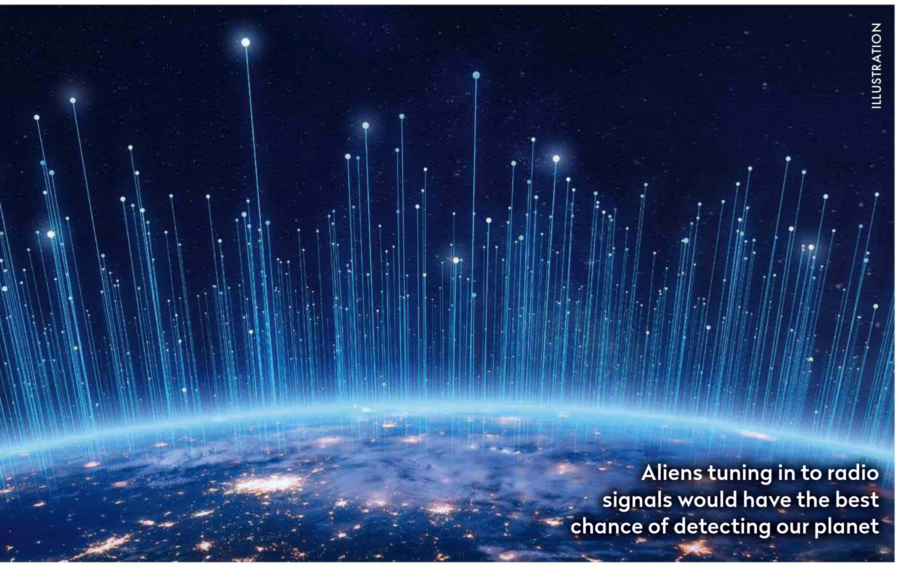
Hera, which launched in October 2024, passed Mars on 12 March during a gravitational-assist manoeuvre on its way to the asteroid Dimorphos. In 2022, NASA's DART spacecraft deliberately smashed into asteroid Didymos's moon Dimorphos as part of a planetary defence mission to test how we might one day deflect a potentially hazardous asteroid. Hera is currently en route to its job observing the effects of that impact, arriving at the Didymos system in late 2026. The Hera team used the Mars fly-by as an opportunity to test Hera's cameras and instruments on Deimos, gaining a unique view of its smallest moon.

"These instruments have been tried out before, during Hera's departure from Earth, but this is the first time that we have employed them on a small distant moon for which we still lack knowledge – demonstrating their excellent performance in the process," says Michael Kueppers, Hera's mission scientist. **www.esa.int**

▲ Smooth, city-sized Deimos was seen from above, appearing to cross the Red Planet

Our experts examine the hottest new research

CUTTING EDGE



Aliens tuning in to radio signals would have the best chance of detecting our planet

Would aliens find Earth?

Researchers ask how far away an alien civilisation could be to detect our planet

The Search for Extraterrestrial Intelligence (SETI) is interested in finding alien civilisations by detecting signs of their activity. The use of radio telescopes to listen out for alien broadcasts dates back to the 1960s, but SETI researchers also look for evidence of enormous engineering projects. For example, an alien civilisation might construct a thin shell around its host star to harvest energy. Such a 'Dyson sphere' ought to be detectable as a warm source of infrared rays without a corresponding visible light source. Astronomers have looked for these telltale signatures but haven't found any.

Many of these 'technosignatures' discussed by SETI researchers relate only to advanced civilisations, far beyond our current level of technological ability (turn to page 65 for more on this). Sofia Sheikh, at the SETI Institute, California, and her colleagues are interested in a slightly different question: how far away would Earth be detectable as harbouring an intelligent species, using only the technology we have today? As the authors put it: "One could imagine a spaceship loaded with all of humanity's best modern-day instruments, launched towards a mirror image of Earth – which present-day technosignatures would be detectable first?"

They look at a range of possible technosignatures: radio emissions; bright lasers shone into the sky; and changes to Earth's atmospheric composition from agricultural and industrial activity.

Starting with radio emissions, the team calculated that if we beamed a signal with the intention of making contact, we'd be able to detect ourselves from around 12,000 lightyears away. Of course, as attempts such as the 1974 Arecibo message have only been sent in the last century, any signals won't have had time to make it nearly that far yet. Meanwhile, inadvertent leaking of much weaker radio waves into outer space, from mobile phone towers or television broadcasts, would be detectable from four lightyears away – only as far as the nearest star to us.

Signs of industry

Indicators of our industrial activity in the atmosphere could be detected from slightly further away. While nitrogen dioxide is produced by lightning and some biological processes on Earth, huge amounts of it are also released by human industrial activity: mainly vehicle engines and fossil-fuelled power stations. Atmospheric nitrogen dioxide peaked in 1980 at levels that ought to be detectable from 5.7 lightyears away with the Habitable Worlds Observatory (HWO), a space telescope due to launch in the 2040s.

> *"Indicators of human industrial activity in the atmosphere, like nitrogen dioxide, could be detectable from 5.7 lightyears away"*

Light pollution is a big problem for astronomers in built-up areas, so might this urban technosignature be detectable? Many cities are lit by the yellowy light from high-pressure sodium lamps, and this is particularly spectroscopically distinctive. Sheikh's team calculates that a telescope like the HWO could detect this artificial light from around 2,300 AU, where 1 AU is the Earth–Sun distance – an alien probe would need to be within the inner edge of our Solar System's Oort cloud to see our nighttime cities.

Sheikh and her colleagues conclude that Earth is most detectable through radio emissions. They stress that there are good reasons to not expect an extraterrestrial civilisation to have reached exactly the same technological level as us, but this work does help focus attention on what sort of technosignatures we might be able to detect on exoplanets.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Earth Detecting Earth: At What Distance could Earth's Constellation of Technosignatures be Detected with Present-day Technology?* by Sofia Z Sheikh et al.
Read it online at: arxiv.org/abs/2502.02614

NICOELNINO/GETTY, NASA/ESA/CSA/STSCI/TEA TEMIM (PRINCETON UNIVERSITY)

Blowing up the Crab Nebula

Pulsar winds may drive the expansion of the 1,000-year-old supernova

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

I've written before in this column of the old adage that astrophysics could be divided into two halves: the study of the Crab Nebula and everything else. While not as true as it once was, this nearby supernova remnant, the result of an explosion witnessed on Earth in the 11th century, still attracts much attention.

Partly this is because it's a dynamic place. The pulsar at its core blinks away, driving material through the nebula. And the Crab itself is expanding fast enough that astronomers have been watching it spread since the 1920s. The authors of this month's paper have been doing just that, comparing images taken with the fabulously named MegaCam and MegaPrime instruments on the Canada–France–Hawaii telescope on Mauna Kea.

Because it's nearby and we can study it in detail, understanding how material moves in the Crab can tell us about the original explosion. We can also learn how the presence of the pulsar affects its surroundings and how the material from the supernova is colliding with and changing its surroundings. The hard bit is disentangling these complex processes and understanding how what must be a three-dimensional structure is seen as a two-dimensional image on the sky.

Moving pictures

The authors start with images from 2009, 2016 and 2019, looking at how each tiny part of the nebula has moved over a decade, ending up with nearly 20,000 measurements of what's called 'proper motion' – the actual movement of the gas.

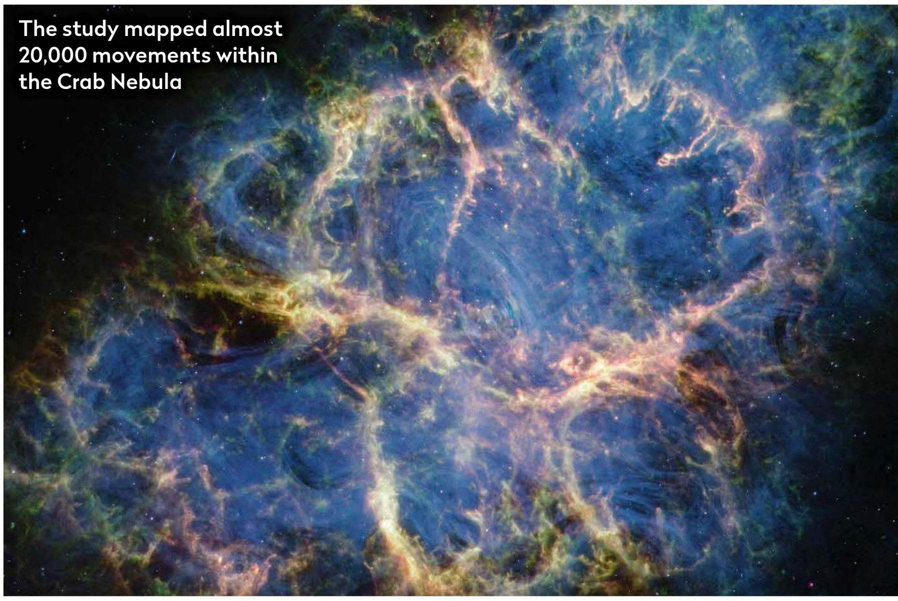
Happily, their measurements make sense. Running the clock backwards and modelling how speeds might have changed over time, they find their measurements are consistent with an initial explosion in the year AD 1105 – which surprised me, because the supernova happened in AD 1054.

What seems to be happening is that the expansion we're seeing now is driven not by the original explosion, but by a wind driven by the pulsar. As the neutron star at the Crab's centre rapidly rotates, its powerful magnetic field can sweep up and accelerate material, shaping what we see today. The familiar Crab Nebula consists both of the supernova remnant and the result of this more recent and ongoing activity, with the wind having 'broken through' the denser inner debris in at least one direction.

"As the neutron star at the Crab's centre rapidly rotates, its powerful magnetic field can sweep up and accelerate material"

Things are still more complicated. The expansion isn't uniform, with the measured speeds changing around the Crab, being slowest along the shorter axis. The authors think this may be the result of a disc of material that was in place around the original star before the explosion. In the past, such a structure has been invoked to explain the surprising brightness of the AD 1054 supernova. The idea is that material from this disc would have been caught up in the initial explosion, so it's interesting that some may have survived in a coherent enough form to influence the shape of the Crab today.

Look at a picture of the Crab taken with a large telescope and you'll be confronted with a mess of structures on all scales, from the disc at the centre of the nebula surrounding the pulsar to the filaments that thread through it. Studies like this one hint at the origins of such complexity and remind us how much work is needed to understand the full story behind even one object in the Universe.



The study mapped almost 20,000 movements within the Crab Nebula

Chris Lintott was reading... *The Non-Uniform Expansion of the Crab Nebula* by T Martin et al. **Read it online at: arxiv.org/abs/2502.19632**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

Armageddon's take on an asteroid strike – a formative movie for the young future astronomer George

George Dransfield recently joined *The Sky at Night* as one of the team of presenters. She tells us what it's like working on one of the BBC's longest-running science shows

When I was asked to join the presenting team on *The Sky at Night*, my PhD supervisor told me I'd landed the most coveted astronomy gig in the UK. I honestly don't know if others covet it, but they should. *The Sky at Night* filming days are just so much fun.

As a former teacher, science communication is something I rank as top-tier important. After all, when we introduce the recipe for 'the scientific method' in Year 7, the final step is communicating your results. In the world of research, this is often limited to presenting at a conference or publishing in scientific journals, with only a few results reaching the general public. But given that so many scientists are publicly funded through research councils, I've always been a vocal advocate for taking our science to the broadest audience possible.

Presenting on the show allows me to do two things I thoroughly enjoy: talking about my own science (exoplanet research) and talking about other people's science. *The Sky at Night* is a bigger platform than I ever could have dreamed of. It means I can have a say not only in the content we present, but also in how it's presented. I can make suggestions for things we should include or questions to ask. I can even pitch cool contributors who I know are doing something super-exciting.

I also get to bombard my interviewees with questions off-camera. I've heard "save it for the interview, George!" a lot, but it's not often that I get a chance to talk to folks in fields so far removed from my own. That's just the nature of research at this level – you become so specialised that it can be rather insular. So hanging out with radio astronomers, space debris experts and instrument designers isn't usually part of an exoplaneteer's work. But it is for me.

Our episode 'Asteroid Strike' (broadcast in April) is a particularly great one. *Armageddon* hit cinemas in 1998 when I was eight years old and, despite its 15 rating, my dad took me to see it (look, it was the '90s). While I now know the science in that movie is questionable (to be polite), I was genuinely struck by how plausible the plot seemed at the time. The passing of the years and the gaining of degrees has taught me that the way the threat of the (implausibly

TOUCHSTONE PICTURES/ALBUM/ALAMY STOCK PHOTO, NASA'S GODDARD SPACE FLIGHT CENTER, NASA/JPL-CALTECH/MSSS

large) asteroid impact was dealt with was bordering on ridiculous, but the scenario is… well, possible? Big space rocks can and have hit Earth. And at least once it went pretty poorly for almost everything around at the time, including the dinosaurs.

When asteroid 2024 YR4 was identified at the start of this year, I consumed the news with a mixture of horror and glee. Horror for obvious reasons, but the glee was because we might get to put the premise of DART to the test for real – exciting and terrifying, in equal measure. By the time it was filming day and I was interviewing Dr Carly Howett, YR4 had been downgraded to a non-issue, but I got to nerd out about all the work being done to better understand the diversity of asteroids in the Solar System, something that's absolutely critical should we ever need to nudge one out of the way.

Whether it's giving talks at a local school, taking part in the Pint of Science festival or presenting on *The Sky at Night*, communicating that better understanding – of asteroids, space and everything else in between – is a huge privilege. The actual doing of science is fun and exciting enough, but sharing it, increasing science literacy and explaining why you can't send Ben Affleck to blow up an asteroid? Priceless.

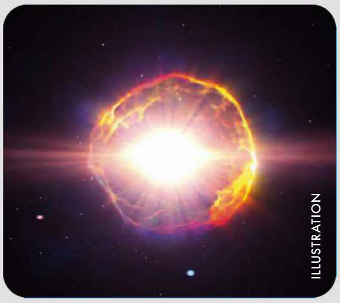
George Dransfield researches exoplanets at the University of Birmingham and is a presenter on *The Sky at Night*

Looking back: The Sky at Night

26 May 1984

Everything on Earth, including you and this magazine you're reading, contain elements created in the heart of a star. The 26 May 1984 episode of *The Sky at Night* looked at exactly how that works.

In the first few minutes after the Big Bang, protons and neutrons formed, combining together to become hydrogen and helium nuclei. After 380,000 years, the Universe cooled enough for them to capture electrons and become fully fledged atoms. Fast-forward 100 million years and these clouds of gas began to come together enough to collapse under their own gravity, becoming the first generation of stars. The pressure inside these stars was so intense that the hydrogen atoms were forced together to form helium atoms. These fusion reactions released energy, which pushed back against gravity and kept stars from collapsing. These stars began fusing heavier atoms, such as nitrogen and carbon, right up the periodic table to iron.



ILLUSTRATION

▲ **No matter where you're from, we really are all made of stardust**

Eventually, they ran out of fuel and went supernova, scattering their elements into the surrounding Universe. They create new gas clouds which form the next generation of stars. While the first generation were huge, these new stars were much smaller. Within their outer layers, elements heavier than iron began to capture neutrons, slowly growing to form heavier and heavier elements.

Over successive generations of stars, the cosmos has been seeded with a rich wealth of elements that allows for the formation of planets, moons and – at least here on Earth – life.

The
Sky at Night
MAY

Secrets of the Red Planet

This episode looks at all things Mars, the planet we've been obsessed with for centuries. But it was when Mariner 4 sent back the first images in 1965 that our neighbour began to feel close enough to touch. Now orbiters have scanned it and rovers have ranged its surface, revealing its watery history and raising the prospect that humans could one day travel there.

BBC Four, **12 May**, 10pm
(first repeat will be on BBC Four, date and time to be confirmed)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ ***The Sky at Night* team investigate all things Mars in May's episode**

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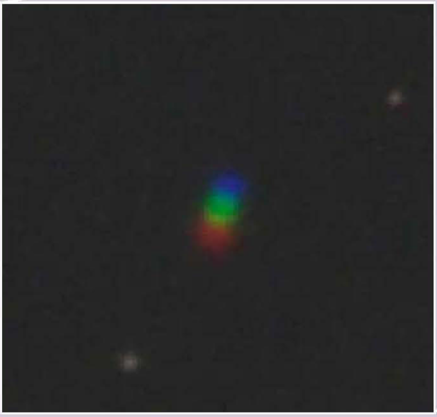
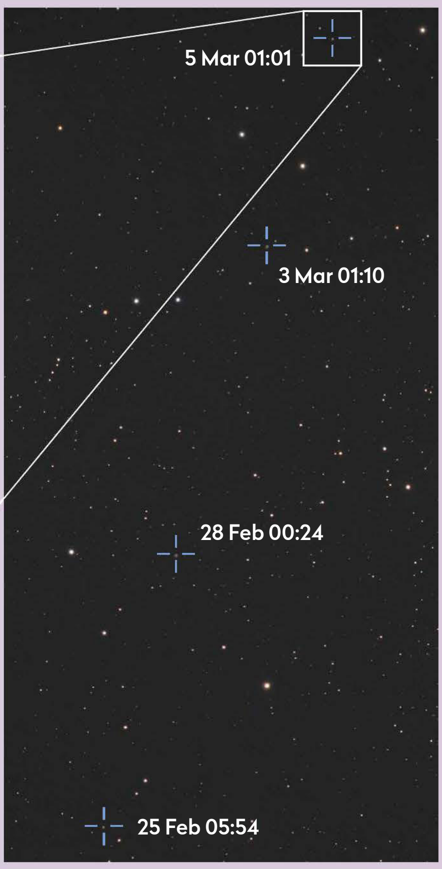
MESSAGE OF THE MONTH

Chasing asteroids

Following the Sky Guide Challenge set by Pete Lawrence in the February issue, I thought I'd share some of my image trials of asteroids 28 Bellona and 8 Flora. I tried both luminance and RGB data to see how it might work, shooting half a dozen two-minute subs on each channel with my ZWO ASI533MM Pro mono camera and Sky-Watcher Esprit 8ED scope on a guided iOptron CEM26 EQ mount.





▲ ▶ Chris took our challenge to capture 8 Flora passing through the stars of Virgo

I used PixInsight to align and annotate the final image with circles and dates for each capture point contained in the mosaic. The RGB image of asteroid Flora is rather interesting: each asteroid point is coloured. Instead of being just a grey, elongated egg with luminance data, each point shows distinct red, green and blue dots. This is the result of there being 12 minutes of data integrated for each colour channel, plus the time it took to autofocus, so around 15 minutes elapsed between each colour integration. If we get any more clear nights, I'll definitely be continuing these tasks. Thanks for the challenge, Pete!

Chris Bowden, via email

That's an excellent capture, thanks for sharing it, Chris. The asteroids are very clear! – ***Pete Lawrence***

Tweet

Barry Clough
@CloughBarry • 14 March
Best I could get of the lunar eclipse in Sussex before low-level mist spoiled things! @skyatnightmag #BloodMoon #fullmoon

Debris dangers

I read with interest your article 'Starship explosion rains down debris' (Bulletin, March 2025 issue). With the success of commercially funded space transport services such as SpaceX and Blue Origin, we are witnessing a period of rapid expansion in satellite launches, most notably, Starlink. I believe the 'risk averse' approach taken by government bodies is correct, but it has, perhaps, created an opportunity to be exploited.

An example came in the early hours of 19 February, when the upper stage of a Falcon 9 rocket entered the atmosphere in an uncontrolled manner, steaking across UK skies before finally making landfall in Poland. I, like many across the UK, witnessed this event (see left, captured by my CCTV). My concern is that as the commercial space industry grows, so too may the pressure to generate ever greater returns to the investor. The increase in profit-driven expansion may also have some negative consequences.

Andrew Richens, Long Sutton, Lincolnshire

Rising stars

As a member of Stratford-upon-Avon Astronomical Society's outreach team, I take no greater pleasure than passing on my passion for astronomy to young people. There is never a session where I'm not asked a question I have to go back ▶

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▶ and research. Their awe and wonder are equal, whether we look at the Moon through a telescope or discover the relative distances to planets using toilet roll.

Recently we went to a local school and this is the feedback we got from the Year 5 students: "They told us interesting facts and we got to wear glasses that allowed us to see the Sun and we looked through telescopes"; "I liked it because they didn't just tell us cool facts, they also did the practical side of things"; "It was a great way to learn about space. I enjoyed every second of it!". Students like them are our future astronomers, astronauts and teachers, and it's up to us to expand their knowledge.

Aide Wakeham, Stratford-upon-Avon

Blood Moon ballad

Thank you for sharing the facts about the 14 March lunar eclipse! ('9 key things to know about this week's blood Moon lunar eclipse', www.skyatnightmagazine.com). I was able to see it clearly near Chicago. I'd love to share with you an original poem I wrote about it:

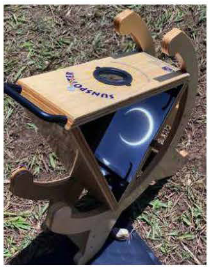
The Moon shines bright
  solely through reflected light.
That proves we're right,
  the Sun's not off at night.
For the Sun sees herself
  in her moons.

Bruce Hiehl, via email

Instagram

kates.universe • 14 March
Lunar eclipse last night was a success! Weather was perfect and the Dwarf II did an awesome job catching it! @bbcskyatnightmag

Sunscreen travels



On 2 October 2024, I was lucky enough to be in the middle of the Pacific Ocean to witness an annular eclipse from Easter Island. It's a bit late, but I thought you might like to see my Sunspotter projector, which I use to view eclipses. It's been to partial solar eclipses with me and shown me two transits of Mercury. I also saw the 2017 total solar eclipse through it in Kentucky. But it was always a dream of mine to see an annular through it.

Linda Manas, Albrighton, Shropshire

SOCIETY IN FOCUS

South Plains Astronomy Club (SPAC) was founded in 1959 under the wide-open spaces of west Texas. We're a small group of amateurs who love to share our enthusiasm, knowledge and love for astronomy with others, so our club has a very active outreach programme.

We provide three public star parties per month. Our primary star party is under the rural skies of Ransom Canyon, while we also organise two urban star parties at the First Friday Art Trail (a local self-guided art tour) and Texas Tech University's monthly Astronight events. We also provide astronomy education for schools and youth organisations, and have led and supported large events, such as outreach at solar eclipses and transits in 2012 and 2024, reaching thousands.

Most of our members are visual observers, but we also have several talented astrophotographers. We enjoy a monthly members-only dark sky party, including at Cat-Star Sky Ranch under Bortle 2 skies. In 2024, a group of members participated in the Patroclus occultation campaign to support NASA's Lucy mission and have begun recording more occultations since then. Several members are currently building a 20-inch Dobsonian telescope for the club. We hope you stop by to say "Howdy!" and join the fun.

▲ SPAC with a long line of visitors waiting to see Jupiter at the First Friday Art Trail

Tom Heisey, SPAC vice president
▶ **www.southplainsastronomy.org**

Perpetual lunacy

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The astronomer's forum

FIELD OF VIEW

Stargazing without stars

Even if clouds stop play, you can still make a cosmic connection, says **Eva Adorisio**

GERHARD VAN WYK/FOLIO

Eva Adorisio writes about travel, culture and the natural world, and has a passion for stargazing

Balancing on tiptoes, I peer into the aged metal telescope, its sheer size acting as a centrepiece in the small room that makes up the observatory. I squint, focusing on the bright-white planet that peeps through the slit in the building's dome. Despite the continuous sheet of cloud blocking most of our starlight, Jupiter shines proudly through the field of view. Seeing this gas giant, I'm amazed that we're able to see the Universe as if it's in arm's reach.

At the Jeremiah Horrocks Observatory in Preston, fellow passionate stargazers are taking their seats around me for the annual Forest of Bowland Dark Skies Festival, a week full of astronomy-themed evenings and, in an ideal world, plenty of stargazing. Unfortunately, this evening's dark sky is obscured by an opaque blanket of thick cloud.

"The two greatest enemies of astronomers are clouds and light pollution," Dermot Gethings, the vice chair of Preston's Astronomical Society, tells us with a chuckle. Dermot begins his presentation by passing around a small chunk of meteorite that is estimated to be 4.5 billion years old. I cradle the extraterrestrial rock carefully in my palms, admiring its reddish tinge and smooth metallic surface. Its shape is irregular with random indentations all over and it's surprisingly heavy for such a small object.

As I inspect it, I contemplate the journey this little space rock must have endured; the thought of the millions of miles it travelled to end up in my hands leaves me feeling utterly awestruck.

Even when the stars aren't visible to the naked eye, we can still feel that sense of connectedness to our Universe. As one of the festival speakers tells us, being an armchair astronomer is more accessible than ever. From learning new constellations using stargazing apps and accessing live images from the Hubble Space Telescope, to attending astronomy events such as the Dark Skies Festival, anyone can feel captivated by the night sky. While living in a city does make stargazing more of a challenge, it's still worth taking a moment to look up.

I often catch myself searching for the stars that manage to sparkle through the light pollution. They are enough to stop me in my tracks and make me feel part of something bigger.

With the last talk of the evening at a close, I leave the observatory feeling mesmerised by our starry skies. I head to my home for the night, a cosy hut at the Dark-Sky-accredited Bowland Escapes, and sit beneath the vast darkness with a warming cup of tea. Surrounded by the quiet Forest of Bowland, the cloud layer seems a little thinner, the light pollution a little lower, and I start to notice twinkling dots all over, faint at first but filled with wonder nonetheless.

As I marvel at the constellations that manage to defy our dark skies' many barriers, I begin to feel that same sense of awe I felt with the meteorite in my hands. I guess you don't need clear skies to appreciate the stars.

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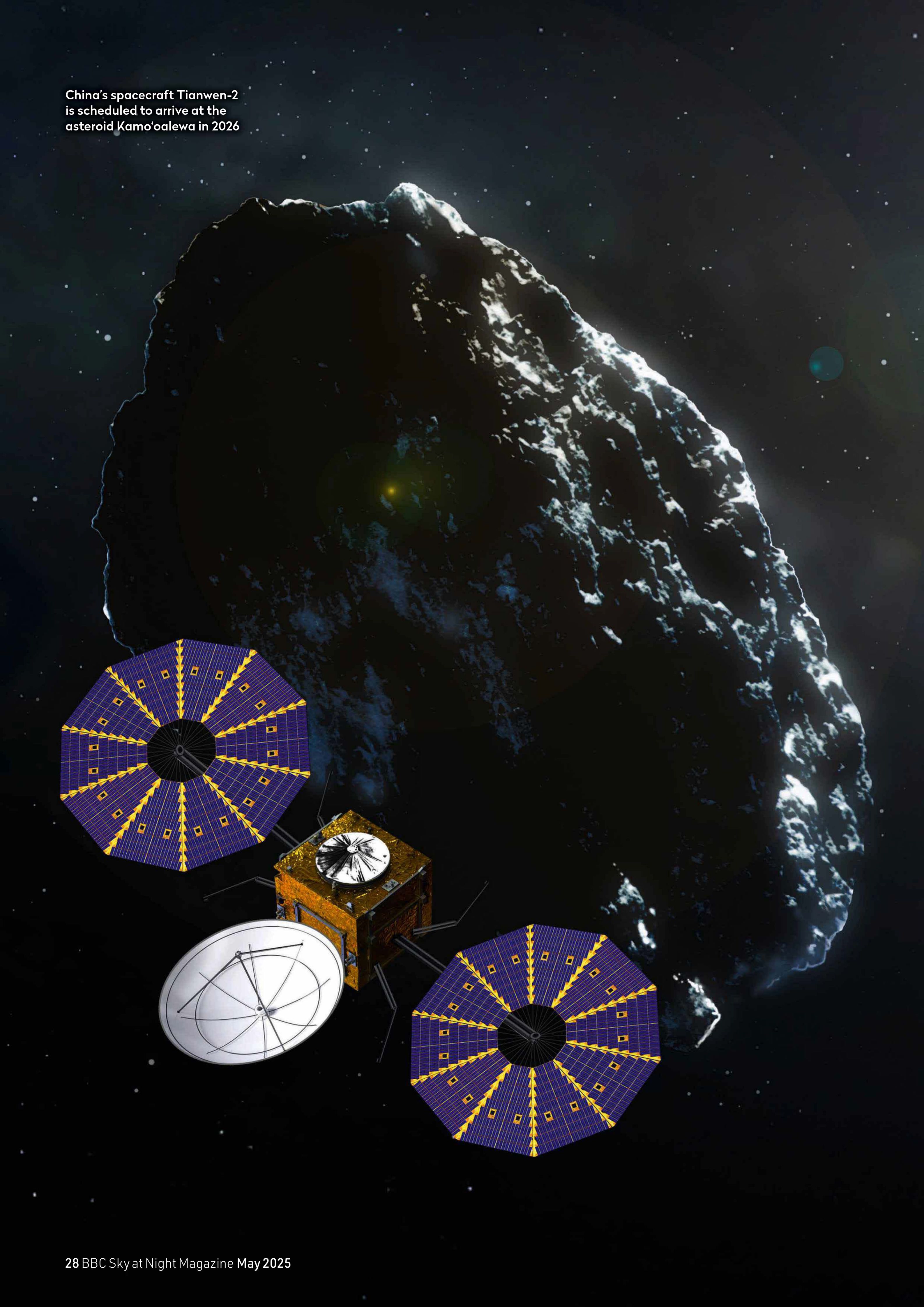

China's spacecraft Tianwen-2 is scheduled to arrive at the asteroid Kamo'oalewa in 2026

ILLUSTRATION: GETTY X 2

Tianwen-2

Unravelling the secrets of asteroids

China is set to mount the latest mission to retrieve a sample of an asteroid and bring it home. **Stuart Atkinson** investigates

Asteroids were once dismissed by astronomers as "the vermin of the skies", constantly getting in the way of more important observations. Not anymore. The former vermin have become one of the hottest areas of space research. Asteroids can reveal the history of our Solar System and offer a tantalising wealth of metals and minerals, not to mention their importance as a threat to our very existence on this planet. This month, China prepares to join in the quest to understand these space rocks with the launch of its most complex planetary mission to date, Tianwen-2. The spacecraft aims to visit not one but two asteroids, returning a fragment of one to Earth and cementing the nation's place as a major player in space exploration.

Cosmic time capsules

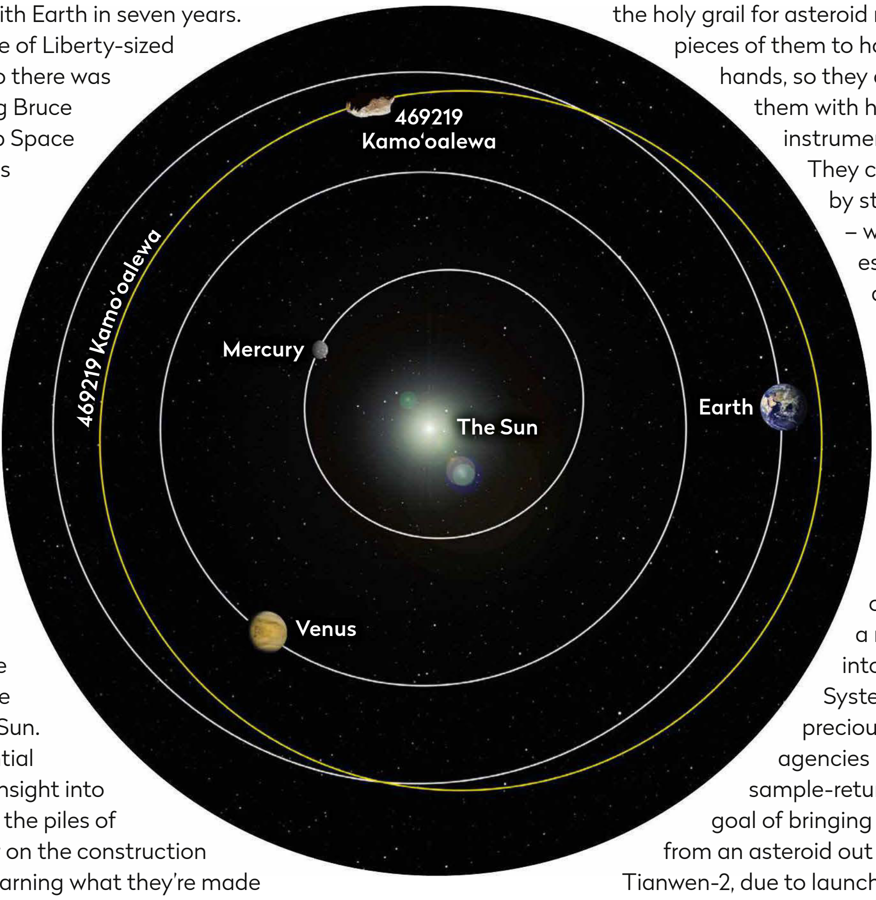
The mission is the latest step in a long journey of learning about these space rocks, which began with the discovery of the first asteroid, Ceres, by the astronomer Giuseppe Piazzi on 1 January 1801. Today, we know the positions and orbits of many thousands of asteroids with great accuracy and more are being found all the time. Around the world, survey telescopes are taking images of the sky, finding asteroids and tracking their orbits around the Sun, some of which pass perilously close to Earth. Eyebrows were raised in genuine concern earlier this year when an asteroid was found that, at first glance, had a small ▶

Asteroids teach us about the origins of our Solar System and life on Earth – they're also a potential threat to our planet

ILLUSTRATION

▶ chance of colliding with Earth in seven years. Luckily for us, the Statue of Liberty-sized 2024 YR4 will miss us, so there was no need to start training Bruce Willis to fly a souped-up Space Shuttle with a nuke in its payload bays.

We won't always be so lucky, and YR4 served as a timely reminder that one day astronomers will find an asteroid on a direct collision course with our planet. When that happens, we'll need a way of either deflecting or destroying it, which means knowing as much about asteroids as possible: what they're made of, how they move and how they orbit the Sun. But as well as our potential end, asteroids offer an insight into our beginning. They are the piles of builder's rubble left over on the construction site of the planets, so learning what they're made of and how they're put together helps us understand the processes that gave birth to the Solar System.



▲ **The Earth-like orbit of Tianwen-2's target, the asteroid Kamoʻoalewa**

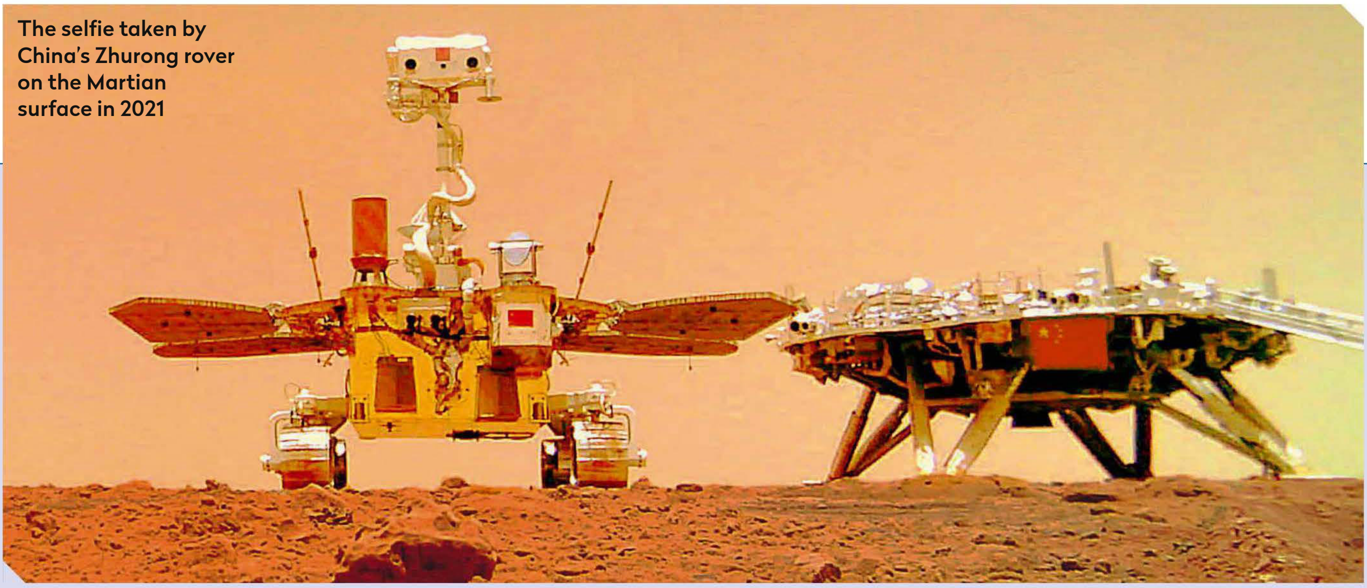
Ingredients of the Solar System

There have been many missions to these wandering space rocks. Some merely snapped a few images on their way elsewhere, while others were dedicated missions to examine specific asteroids. Ultimately, the holy grail for asteroid researchers is having pieces of them to hold in their gloved hands, so they can interrogate them with high-tech scientific instruments here on Earth.

They can do this to a degree by studying meteorites – which are, after all, essentially pieces of asteroid that have landed on Earth – but these have been contaminated by our planet's weather and environment. What scientists want is a pristine sample, unchanged for billions of years, giving them a much greater insight into the past of the Solar System itself. To fetch these precious payloads, space agencies have mounted several sample-return missions, with the goal of bringing back a small piece from an asteroid out in space.

Tianwen-2, due to launch this month, is such a mission and the latest in a long line of increasingly ambitious Chinese space exploration projects. The mission has multiple aims, but its primary goal is to rendezvous with and then collect samples from the near-Earth asteroid 2016 HO3, also known as 469219 Kamoʻoalewa. The Tianwen-2 team chose this asteroid because it is a 'quasi-satellite' of Earth, meaning it orbits the Sun on a path similar to Earth's

MIKDAM/GETTY, XINHUA/ALAMY STOCK PHOTO, NASA, NASA/GSFC/ARIZONA STATE UNIVERSITY

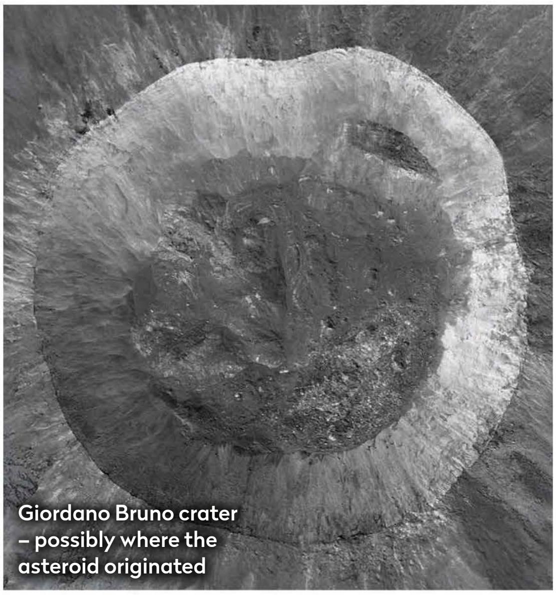

The selfie taken by China’s Zhurong rover on the Martian surface in 2021

China’s planetary ambitions

The nation is becoming an increasingly important space power

After years in NASA’s shadow and perhaps not being taken entirely seriously by some, the Chinese space programme is now advancing relentlessly. While China likes to keep its cards close to its chest when it comes to its space endeavours, we do know it has ambitious goals. Two Chinese Yutu rovers have trundled across the Moon and their Zhurong rover has driven across the rust-hued plains of Mars. Soon after landing, Zhurong even took a ‘selfie’ with a small camera it dropped onto the ground, striking a cheeky, head-tilted pose. China now has its own space station with a modular design like the ISS. Tiangong now has four modules, multiple solar arrays, docking ports and a robot arm. Its taikonauts are conducting exciting scientific research and learning a lot about living in space for long periods, in preparation for their next giant leap: to the Moon. China’s goal is to land people on the Moon “by 2030”. They have already designed the rocket and spacecraft they’ll use and the spacesuits too. They also have well-developed follow-on plans for lunar habitat modules, power plants and rovers to support a permanent presence on the Moon. Meanwhile, NASA’s Artemis programme has been plagued by so many delays that many experts believe China could land people on the Moon before NASA does. Perhaps when the Artemis III astronauts do eventually land, they will find Chinese taikonauts waiting there to greet them.

▲ **Kamo‘oalewa’s spectrum seems to match Moon rocks brought back by Apollo 14**


Giordano Bruno crater – possibly where the asteroid originated

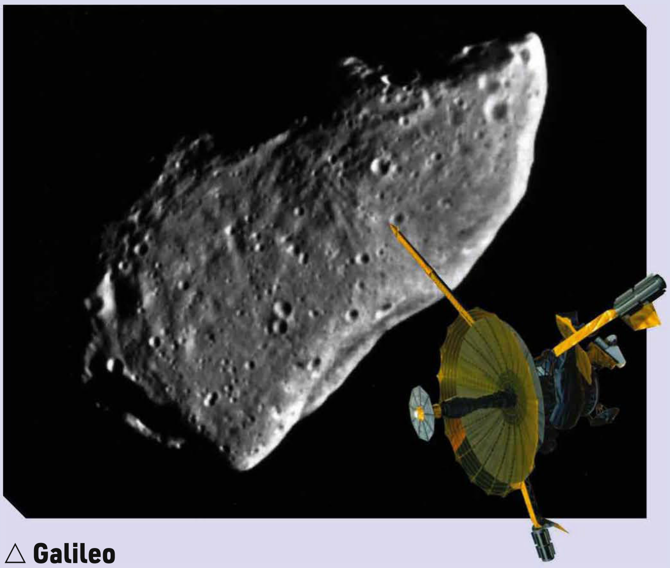
and even seemingly went into orbit around our planet for a few months in 2024. There’s even a chance it could one day strike Earth; at 40–100 metres across, it would be large enough to take out a city – but that won’t happen for at least another 100 million years.

What is Kamo‘oalewa?

Ahead of the mission, astronomers have been studying the asteroid in detail to learn what they can from here on Earth. Kamo‘oalewa seems to have a similar light fingerprint, or spectrum, to lunar rocks brought back by Apollo 14. This has led to theories that the asteroid may in fact be a lump of Moon rock ejected by another, much larger, asteroid striking the surface. The most likely candidate is the impact which created the 22km-wide (14 miles) Giordano Bruno crater on the lunar far side four million years ago. Another study examined how the Sun affects the orbit of the asteroid, both via the gentle push of the solar wind and as a side effect of sunlight heating the rock, known as the Yarkovsky effect. Understanding how these impact an asteroid’s path ▶

Seven major asteroid missions

Previous spacecraft that have paid a visit to an asteroid

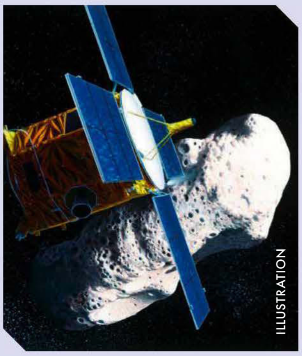


△ Galileo

This NASA mission, primarily aimed at studying Jupiter (and now infamous for the failure of its primary communications antenna dish to unfurl properly) encountered two asteroids: Gaspra in 1991 and Ida in 1993. The probe flew past the asteroids without stopping but provided fascinating images and very valuable data about their surfaces and composition.

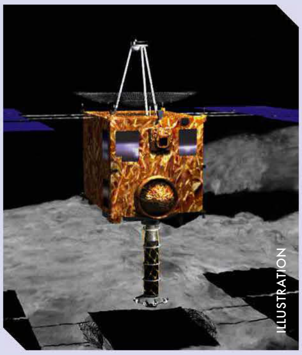
NEAR Shoemaker ▷

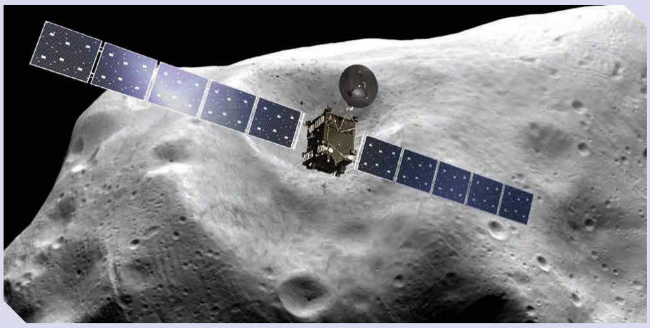
Launched in 1996, this history-making NASA mission, named after scientist Gene Shoemaker, was the first to orbit and land on an asteroid. In 2001, it touched down on the saddle-shaped asteroid 433 Eros, not only sending back incredibly detailed images of the craters on its surface but detailed information about its structure too.



Hayabusa ▷

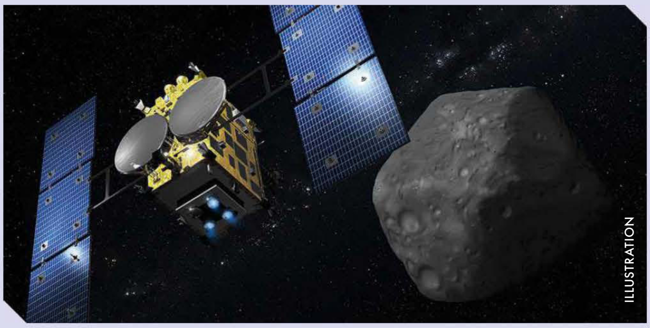
This Japanese mission, launched in 2003, visited the asteroid Itokawa in 2005 with the aim of returning a sample of space rock to Earth. While en route, Hayabusa was struck by the largest solar flare in recorded history. Despite this, it successfully collected a sample and even returned it to Earth in 2010 – though the final sample was less than 1g.





△ Rosetta

Before going into orbit around comet 67P/Churyumov–Gerasimenko and dropping a small lander onto its dusty surface, this hugely ambitious European Space Agency probe flew by two asteroids, Šteins in 2008 and Lutetia in 2010, capturing detailed images and data before continuing to its cometary close encounter.

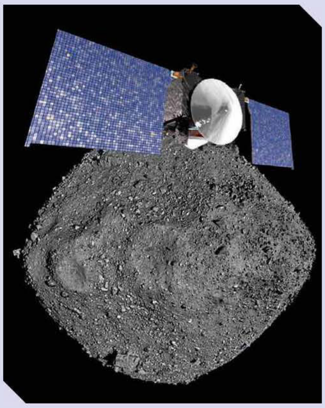


△ Hayabusa2

Japan's space agency launched its second run at an asteroid sample-return mission in 2014, reaching near-Earth asteroid Ryugu in 2018. For the next year and a half, it surveyed the asteroid and collected samples that it brought back to Earth in December 2020. It also deployed four small rovers on the asteroid which had their own cameras and instruments.

OSIRIS-REx ▷

Launched in 2016, OSIRIS-REx arrived at the near-Earth asteroid Bennu four years later and collected samples that returned to Earth via a capsule in 2023. They included black rocks, stones and dust, precious samples that are now being studied all around the world. The craft is now on a new mission to the asteroid Apophis and has hence been rechristened OSIRIS-APEX.

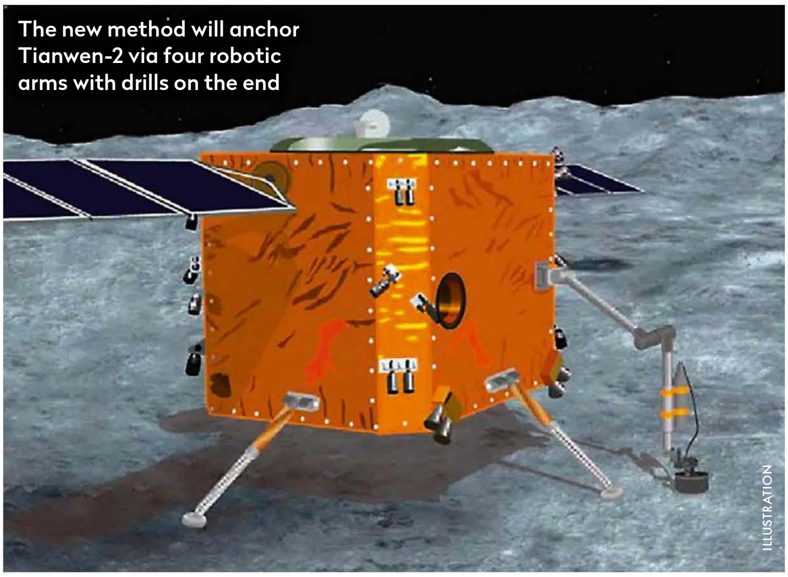


DART ▷

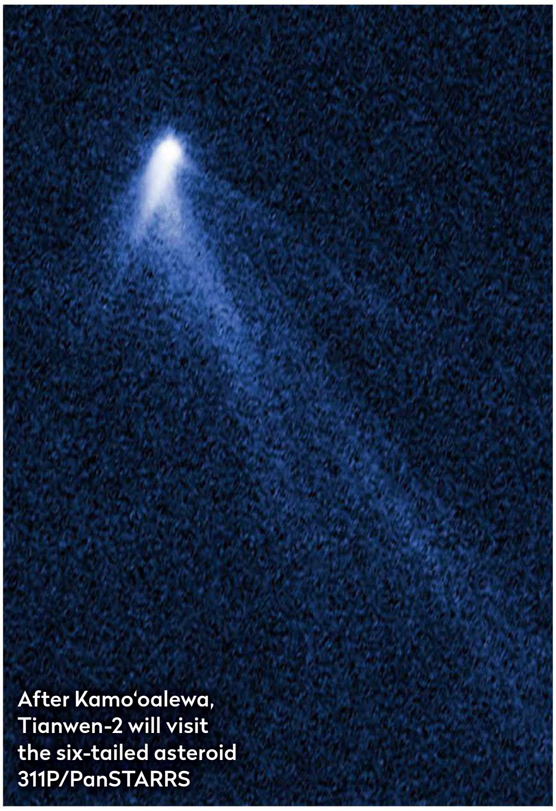
In 2022, NASA's Double Asteroid Redirection Test (DART) mission rendezvoused with the asteroid Didymos, but instead of simply studying it, the probe deliberately crashed into its moonlet, Dimorphos. This was to test the feasibility of deflecting an asteroid which might threaten Earth in the future – and it succeeded, shortening the moonlet's orbit around its parent asteroid by more than 30 minutes.

NASA X 3, JSC, JAXA, ESA 2010 MPS FOR OSIRIS TEAM MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA, JAXA/AKIHIRO IKESHITA, NASA/JOHNS HOPKINS APL, NASA/GODDARD/UNIVERSITY OF ARIZONA, TAO ZHANG/KUN XU AND XILUN DING/NATURE ASTRONOMY, NASA/ESA AND D. JEWITT

◀ Bite the dust: OSIRIS-REx used a touch-and-go method to briefly land and snatch a sample of Bennu



The new method will anchor Tianwen-2 via four robotic arms with drills on the end



After Kamo'oalewa, Tianwen-2 will visit the six-tailed asteroid 311P/PanSTARRS

> “Tianwen-2 will have a significant challenge as the asteroid Kamo‘oalewa rotates once every 27 minutes”

▶ will allow astronomers to better predict their orbits. In both cases, Tianwen-2 will be able to deliver even more insight when it arrives at the asteroid in 2026.

How to grab an asteroid

When it comes to collecting the sample, Tianwen-2 will have a significant challenge as the asteroid rotates once every 27 minutes – the fastest rotation any such mission has faced. The spacecraft will trial two methods of collecting the precious asteroid dust.

The first will be to use the same ‘touch-and-go’ method of collecting asteroid dust as employed by previous sample-return missions Hayabusa2 and OSIRIS-REx, where the craft will only briefly approach the surface to snatch the sample. The second will be the first-ever attempt at an ‘anchor-and-attach’ acquisition. This is a much more complex manoeuvre, requiring the spacecraft to autonomously approach the asteroid, assess the landscape and then fix itself to the surface.

This will allow the spacecraft to make a much more controlled collection using a mechanical arm. Once collected, those samples will be safely stowed in a capsule and dispatched back to Earth in 2027, roughly two and half years after launch.

But its mission still won't be finished. Once it is done at Kamo‘oalewa, the orbiter will then depart from the asteroid and set off on another journey to explore an active asteroid named 311P/PanSTARRS. This unusual object has the characteristics of both an asteroid and a comet, essentially offering a ‘two-for-one’ target that will give valuable insights into the composition and evolution of small celestial bodies.

Tianwen-2 (*tianwen* meaning ‘questions to the heavens’) is named after an ancient Chinese poem symbolising the quest for knowledge – very fitting, as it's now clear that the Chinese space programme is engaged in an exciting quest to explore the Solar System and gather as much knowledge as possible. Hopefully, the samples Tianwen-2 collects from its asteroid target will not only increase our understanding of asteroids but also help us prepare better for when we find ourselves in the cosmic crosshairs of one heading our way.

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

Europe's gateway to space, the European Space Agency unites 23 countries in the study and exploration of the Universe

ESA

50 years of the European Space Agency

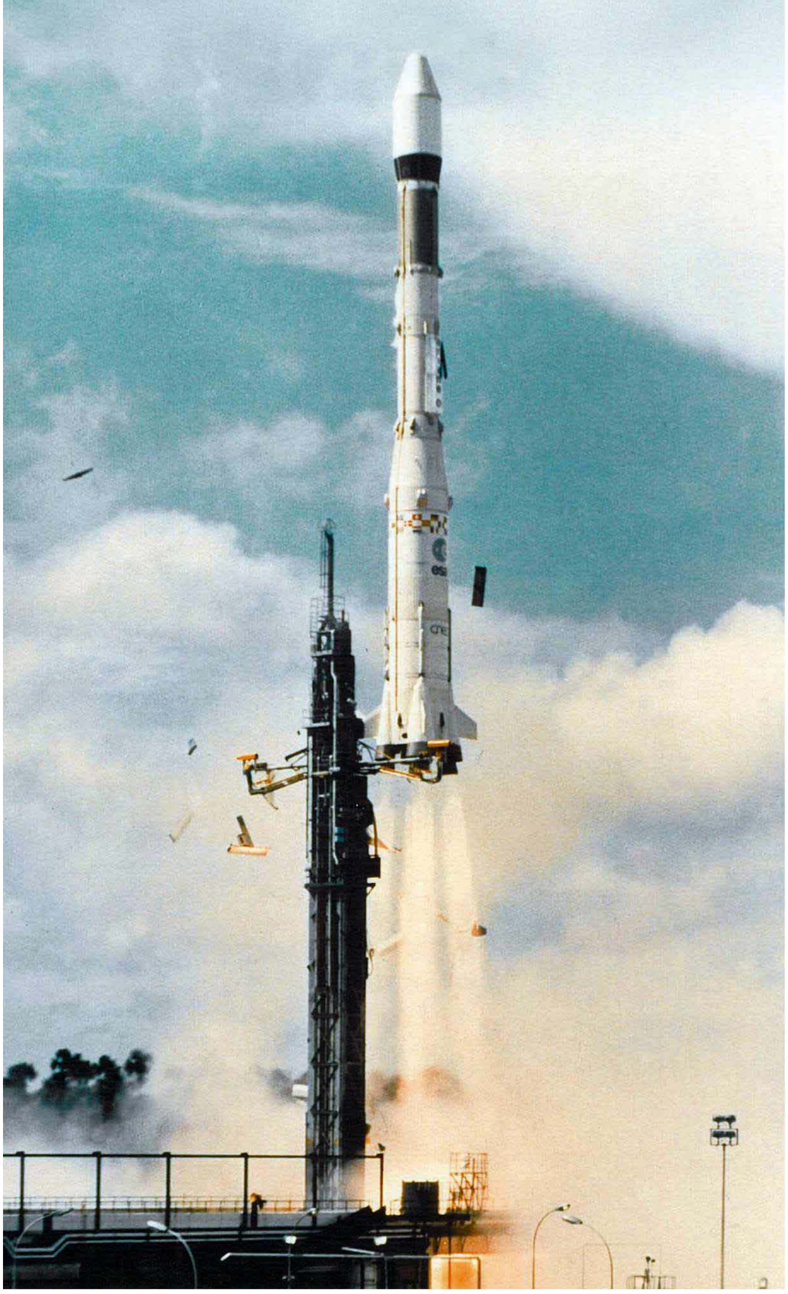
As Europe's organisation for space exploration marks five decades since its foundation in May 1975, **Anita Chandran** looks at key moments in its history

In 2025, the European Space Agency (ESA) will reach a significant milestone: its 50th birthday. For the last five decades, ESA has brought together European countries for sustainable and collaborative space exploration, launching missions like the Cassini–Huygens probe in 1997, which ranged as far as the rings of Saturn.

ESA emerged from the need for a multinational European space programme, particularly to compete with the strength of research being produced by the USA and Soviet Union after World War Two. The organisation can trace its roots back to two separate European space agencies set up in the 1960s: the European Launch Development Organisation (ELDO), which sought to develop a launch system; and the European Space Research Organisation (ESRO), which focused on developing spacecraft. In 1975, ELDO and ESRO were merged into what is now ESA, composed then of just 10 member states.

Since its formation, ESA missions have shaped our understanding of space and advanced the technology we use for astronomy. Its first mission, Cos-B, which launched in 1975 and aimed to study gamma radiation emitted from astronomical objects, operated for four years longer than planned. Only a handful of gamma-ray sources were known before Cos-B. ESA's Integral, launched in 2002, has now taken up its mantle, investigating gamma-ray bursts by detecting not only gamma rays, but X-rays and visible light.

Today, ESA aims to provide cooperation in space research among ▶



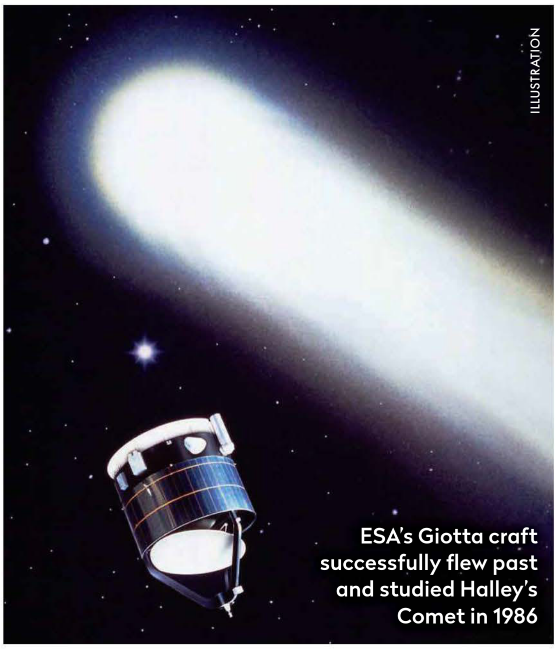
▲ **Europe launches its own Ariane and Vega rockets from its spaceport in French Guiana**

▶ European states in a peaceful way, with the view of using research and technology for scientific purposes and space operations. It consists of 23 member states and has over 2,500 employees across its nine sites. Over its last 50 years, it has demonstrated science that has captured the imagination of people across the world, providing infrastructure for researchers and citizens, as well as shedding light on some of the Universe's most challenging problems.

ESA's missions have spanned our Solar System, looked into the early Universe, and kept an eye on Earth. It works closely with NASA and with other international astronomical organisations, like the European Southern Observatory. Its projects are numerous and many of them have household acclaim. In celebration of ESA's anniversary, let's take a look at some of its biggest achievements in the last half-century.

Ariane: a rocket for Europe

One of ESA's biggest contributions to the space sector has been the development of the Ariane satellite-launcher programme. Started in 1979, Ariane aimed to enable Europe to have independent access to space. The small satellite launchers that were used in Europe prior to Ariane, such as Diamant A and B, were successful but not suitable for large payloads. Europe needed a larger, more flexible launch system.



ESA's Giotto craft successfully flew past and studied Halley's Comet in 1986

One of ESA's precursors, ELDO, was developing a satellite launcher called Europa, which relied on elements from different European nations – the UK, Germany and France. The project was plagued with technical failures. An ELDO rocket was 'successfully' launched in 1964, but became highly unstable at around two minutes into its flight and eventually broke up. By 1973, the European rocket programme had been shelved.

In the wake of these failures, France proposed the Ariane project as a replacement for Europa, under the guise of L3S (an abbreviation of the French for third-generation substitution launcher). Ariane-1 had a dramatic start at its first attempt on 15 December 1979, with the rocket motor abruptly going out. It launched successfully nine days later from Kourou, French Guiana on 24 December 1979. While Ariane-1's purpose was to send satellites into geosynchronous orbit, it was particularly important because of its capability to send a pair of satellites on a single launcher, reducing costs.

The Ariane series of rockets has had a significant impact on European spaceflight, launching satellites such as Giotto, ESA's first deep-space mission to Halley's Comet; Envisat, an Earth-observing satellite that was the largest of its kind at the time; and Rosetta, the comet-chaser. Its most recent iteration, Ariane 6, was successfully launched in 2024.

Journey to the surface of Titan

A mission that captured the hearts of many, and perhaps one of ESA's most spectacular, Cassini–Huygens took a space probe all the way to Saturn. The craft was composed of both NASA's Cassini space probe and ESA's Huygens lander, which eventually landed on Titan, Saturn's largest moon. To date, it remains the furthest landing from Earth ever made.

Launched in 1997, Cassini–Huygens reached Saturn in 2004, where it remained until 2017. In the 1990s,

ESA (1980), ESA X 2, ESA/SCIENCE OFFICE, ESA/NASA/JPL/UNIVERSITY OF ARIZONA, NASA/JOHNS HOPKINS APL/STEVE GRIBBEN

Cosmic Vision set ESA's sights on missions that answer the Big Questions about the Universe

ILLUSTRATION

ESA's future missions

Planning is already under way for the next 50 years of European space missions

Running up to its 50th birthday, ESA has announced a diverse range of future missions for its next half-century. These fall under two strategic science programmes: Cosmic Vision, ESA's current planning cycle that will run missions until 2035; and large-class missions for 2035–2050 that fall under the Voyage 2050 planning cycle.

Cosmic Vision

This programme asks four major science questions:

▶ What are the conditions for planet formation and the emergence of life?

▶ How does the Solar System work?

▶ What are the fundamental physical laws of the Universe?

▶ How did the Universe originate and what is it made of?

Voyage 2050

This programme will turn its focus to three themes:

▶ Moons of the giant planets, which will build on the Cassini–Huygens Saturn mission and the Jupiter Icy Moons Explorer (Juice) mission, to investigate the habitability of worlds in our Solar System.

▶ From temperate exoplanets to the Milky Way, it will investigate the ecosystem of our Milky Way, using our local Galaxy as a laboratory for understanding galaxies in general.

▶ New physical probes of the early Universe, to look at outstanding questions in fundamental physics and astrophysics, and phenomena like gravitational waves or the cosmic microwave background to better understand big questions such as how the Universe began.

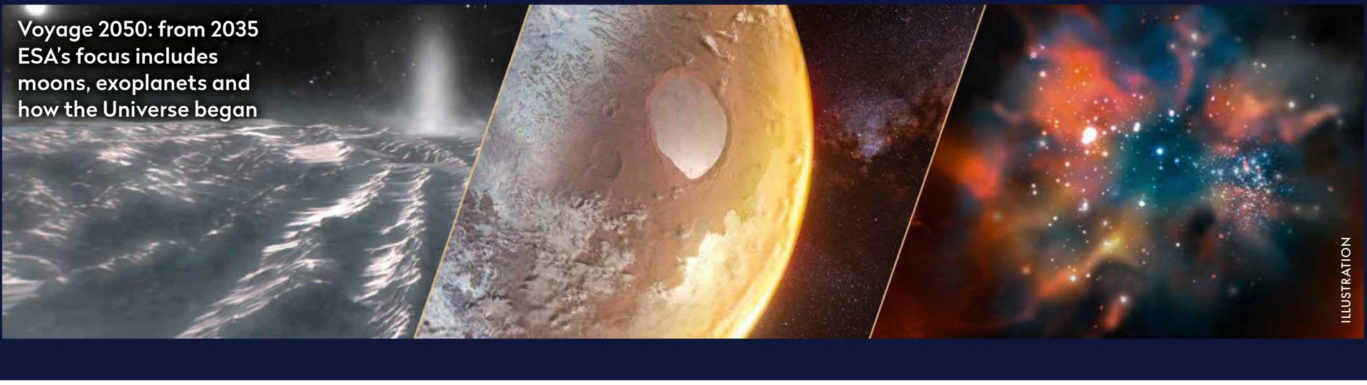
Upcoming ESA missions

▶ **2026: PLATO** (Planetary Transits and Oscillations of stars), an exoplanet-hunter that will look for worlds in the habitable zone of Sun-like stars, as well as measuring exoplanet size, discovering exomoons and searching for rings around them.

▶ **2029: ARIEL** (Atmospheric Remote-sensing Infrared Exoplanet Large-survey), which will examine the atmospheres of 1,000 planets in our Galaxy from a vantage point at Lagrange Point 2.

▶ **2035: LISA** (Laser Interferometer Space Antenna), an instrument formed by three spacecraft, designed for sensitively detecting gravitational waves.

▶ **2037: NewAthena** (New Advanced Telescope for High-Energy Astrophysics), an X-ray observatory for mapping hot clouds of gas, such as around black holes.



Voyage 2050: from 2035 ESA's focus includes moons, exoplanets and how the Universe began

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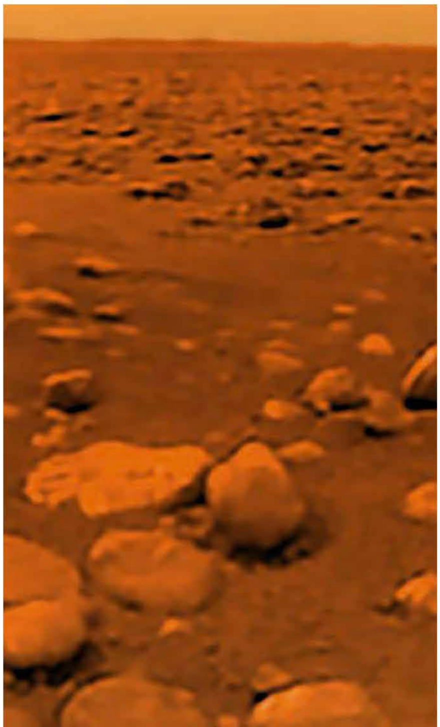
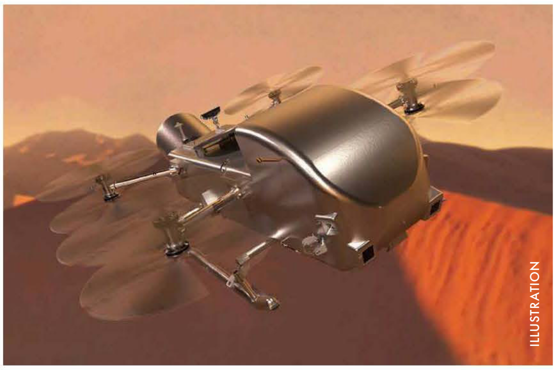




ILLUSTRATION

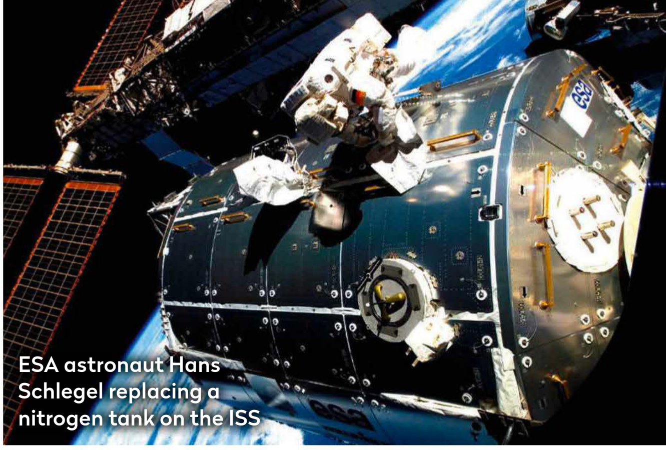
▲ The upcoming Dragonfly rotorcraft will follow the trail blazed by ESA's Huygens lander

◀ Titan's surface, photographed by the Huygens lander in 2005

the joint NASA/ESA Hubble Space Telescope had spotted an unusual patch on Titan's surface. Both Cassini and Huygens were able to solve the mystery of this feature as they observed Titan both from afar and up close, taking multiple pictures from orbit and during Huygens' landing on the moon. The probe's descent took two and a half hours under parachute and eventually revealed the features similar to rivers and seas we have on Earth. Unlike our planet, however, these features were caused by liquid ethane and methane.

Extraordinarily, Huygens transmitted its information to Cassini, which was still in orbit around Saturn. This data was relayed home, but an ▶

▲ **Rosetta rendezvoused with comet 67P/Churyumov–Gerasimenko and even dropped a robot lander onto its surface in 2014**



ESA astronaut Hans Schlegel replacing a nitrogen tank on the ISS

ESA's Columbus lab on the ISS is used for testing the effects of outer space

▶ error meant that only half of Huygens' data was recorded. The invaluable half that was received has been instrumental in our understanding of Saturn and laid the foundation for NASA's Dragonfly mission, proposed to launch in 2028, which will return to the surface of Titan, this time with a robotic rotorcraft.

Comet-chasers

In 2004, ESA launched Rosetta, an ambitious comet-hunting mission, to track down and land on the comet 67P/Churyumov–Gerasimenko during the two-year period when it was closest to the Sun in its orbit. Rosetta consisted of an orbiter, a lander called Philae and over 20 scientific instruments. To intercept Churyumov–Gerasimenko, the probe had to receive numerous assists from Earth's gravity, enter a period of deep-space hibernation and then perform a series of complex rendezvous manoeuvres.

Ten years after its launch, in August 2014, Rosetta caught up to Churyumov–Gerasimenko. A few months later, in November, it deployed the Philae lander to the comet's surface, the first-ever landing on a comet. It was a myriad of firsts: the first comet rendezvous, the first tracking of a comet on its orbit around the Sun and the first landing on a comet's surface.

Philae's battery ran down just two days after landing on the comet, but before its loss of power it was able to detect the presence of organic compounds, the building blocks for life, in the comet's atmosphere. Comets can act like time capsules, and measurements from the surface of Churyumov–Gerasimenko have shed light on the history of our Solar System. While Philae briefly gained power again in June 2015, Rosetta's communications with the lander were turned off in July 2016. Rosetta's impressive tour of the Solar System ended in a controlled hard landing on Churyumov–Gerasimenko in September 2016.

ESA in numbers

23 member states, plus associate members including Canada

9 facilities, including a launch base in French Guiana

Over 68,000 publications based on ESA mission data (as of 2021)

Over 225 successful rocket launches

2,547 staff members, from admin to rocket scientists

€7.68 billion budget in 2025

16 current missions, comprising 21 spacecraft (excluding the JWST and the ISS, which are hosted by NASA/Roscosmos)

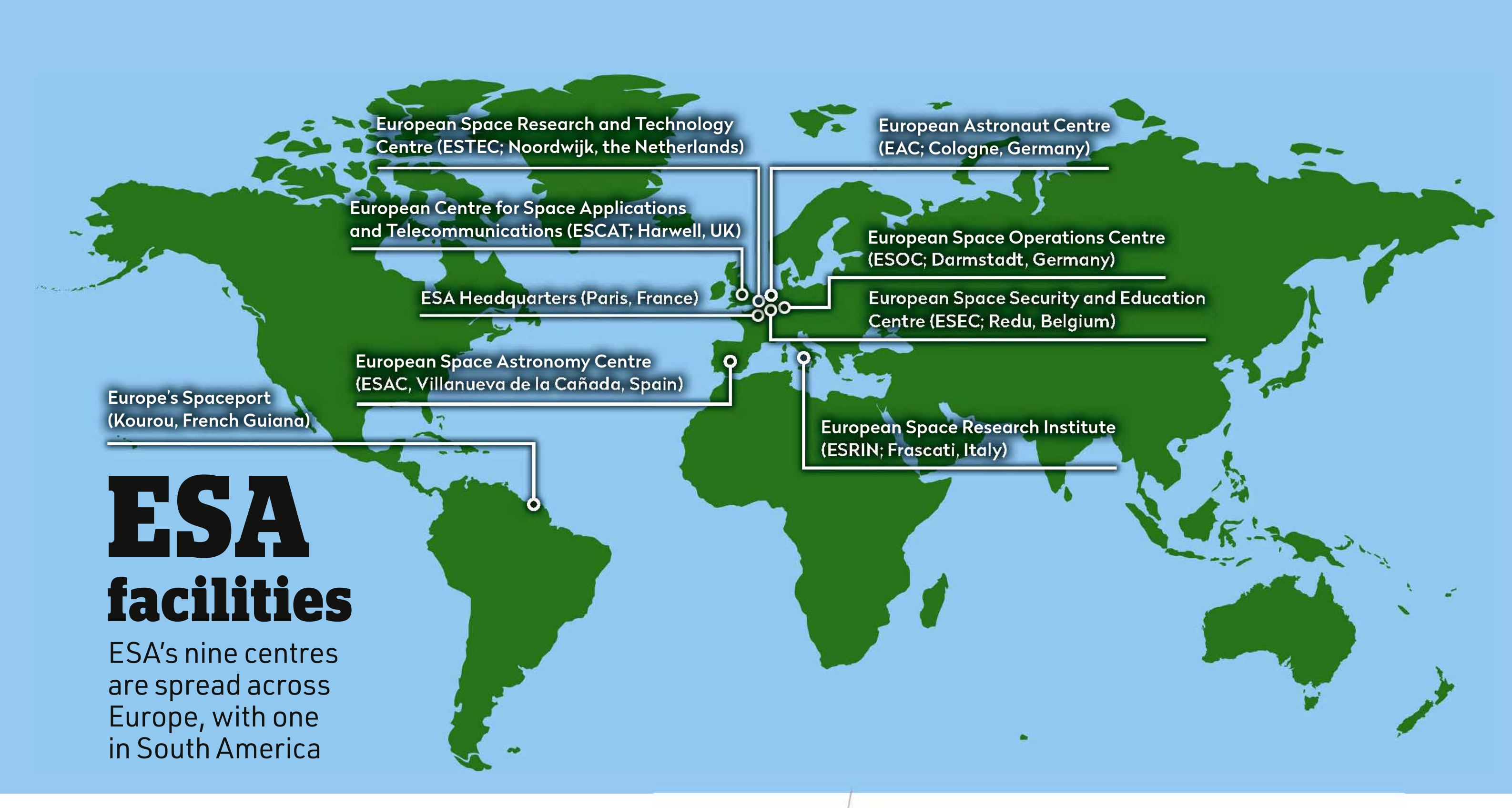
91 total missions (past and present)

7 upcoming major missions, from hunting planets to intercepting comets

Laboratories of the sky

Europe's largest contribution to the International Space Station is its Columbus module, a science laboratory. It was delivered by NASA's STS-122 mission in 2008 and ever since has functioned as a laboratory for multidisciplinary research under microgravity. At around 7 metres (23ft) long and 4.5 metres (15ft) wide, Columbus also houses four

ESA/ROSETTA/NAVCAM, ESA/NASA, ESA, NASA/ESA/CSA/STSCI/JOSEPH DEPASQUALE (STSCI)/ ANTON M. KOEKEMOER (STSCI)/ALYSSA PAGAN (STSCI)


European Space Research and Technology Centre (ESTEC; Noordwijk, the Netherlands)
European Astronaut Centre (EAC; Cologne, Germany)
European Centre for Space Applications and Telecommunications (ESCAT; Harwell, UK)
European Space Operations Centre (ESOC; Darmstadt, Germany)
ESA Headquarters (Paris, France)
European Space Security and Education Centre (ESEC; Redu, Belgium)
European Space Astronomy Centre (ESAC, Villanueva de la Cañada, Spain)
Europe's Spaceport (Kourou, French Guiana)
European Space Research Institute (ESRIN; Frascati, Italy)

ESA facilities

ESA's nine centres are spread across Europe, with one in South America

platforms on its outer wall to which experiments can be attached, meaning researchers can expose their experiments directly to outer space and its hostile conditions: vacuum, powerful radiation, microgravity and temperatures approaching absolute zero.

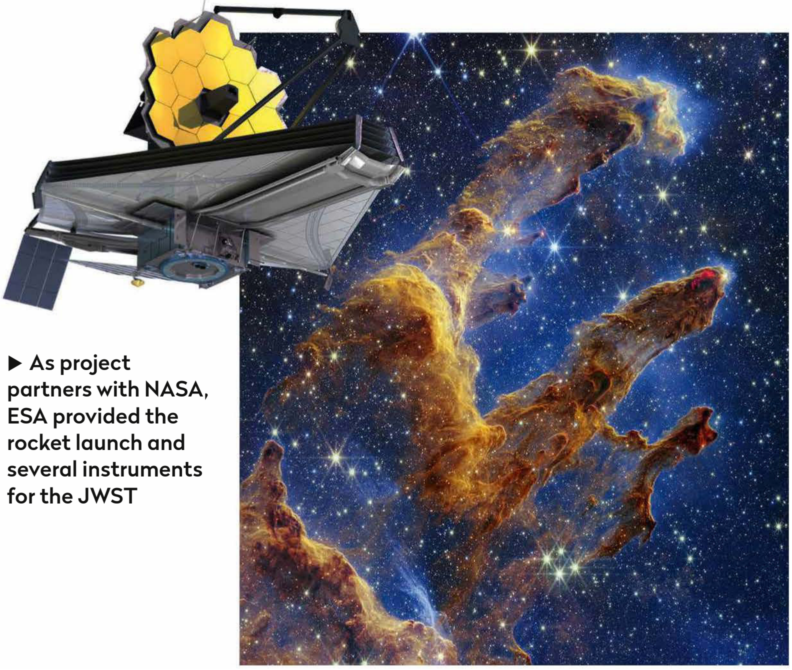
Hundreds of experiments have been undertaken on Columbus, enabling studies of quantum physics, the effects of reduced gravity on the human body and the viability of living cells in space transit. Columbus's outdoor platforms were used to house bacteria, lichen, algae and even seeds for 18 months without protection; upon returning to Earth in 2009, the lichen awoke from dormancy, suggesting that life could possibly survive in the harsh environment of space, perhaps on the back of an asteroid ready to deposit it on a planet like Earth.

JWST and Hubble

In December 2021, ESA launched the James Webb Space Telescope (JWST) in collaboration with NASA. Since then, the JWST has been instrumental in furthering our understanding of the early Universe, galaxy formation and exoplanets.

JWST has been a feat of engineering, with a primary mirror composed of 18 honeycomb-like segments, amounting to an overall diameter of 6.5 metres (21ft). JWST's primary mirror was so large it had to be folded for launch and deployed in space. The observatory operates in the infrared, complementing the data received from the Hubble Space Telescope, launched in a partnership between NASA and ESA in 1990.

Both Hubble and JWST have pushed the frontiers of human vision, enabling us to look further and further back into the history of the Universe and to answer questions that were previously beyond our comprehension. They have also produced some of the most iconic images of space in our lexicon, such as the Hubble Ultra Deep Field, a view of nearly 10,000 galaxies in a small patch of sky; and Webb's view of the Pillars of Creation, a star-forming region within the Eagle Nebula, 6,500 lightyears away.



▶ **As project partners with NASA, ESA provided the rocket launch and several instruments for the JWST**

ESA has been a mainstay of global astronomy for the last half a century. ESA technology, laboratories and scientists have moulded the landscape of space exploration, and ESA missions continue to push the frontiers of space travel. In the coming handful of years, its missions will continue to flourish. The Jupiter Icy Moons Explorer (Juice) – launched in 2023 – will reach the gas giant by 2031; the Lunar Gateway, the first international space station to orbit the Moon, is now under construction; and programmes like the Rosalind Franklin rover, set to launch in 2028, will soon tell us about the possibility of life on Mars. ESA's longer-term future also looks bright, with projects being designed to answer big questions about the nature of the Universe. If the last 50 years were anything to go by, the next 50 will bring even more successes.

Anita Chandran is a physicist, science writer and editor based in London

How animals use the stars

The animal world is intricately entwined with the night sky. Naturalist **Megan Shersby** looks at some fascinating ways that animals take their cues from the cosmos

Humans have long marvelled at the night sky above us, inspired by the Moon and the stars to invent stories and myths, travel the oceans and learn more about the Universe in which we live. At the same time, animals have also been using celestial cues to orient themselves. From tiny foraging ants and dung-rolling beetles using moonlight, to birds navigating their migration by the stars, a wide variety of species rely on the night sky to thrive and survive.

Sea turtles head to moonlit waters after burying their eggs

Sea turtles

Both the female turtles that lay their eggs on their natal beach and the hatchlings that emerge a few weeks later head towards the brightest horizon to enter the ocean, where the water reflects the light of the Moon – avoiding the darker landward silhouettes.

However, artificial lights from urban developments disorient them and they can end up circling the beach in confusion or worse, head towards our roads and buildings – sometimes with fatal consequences.

◀ **Without darkness and moonlight, moths get trapped in a loop of bulb-bashing**

Moths

It's well known that many moth species will fly towards a candle, lamp or other light source – a behaviour called positive phototaxis – and it's been theorised that this is because they are mistaking it for a celestial cue that they would use for orientation.

A recent study using three-dimensional flight data suggests that nocturnal moths turn their back on the brightest light – historically the Moon and the sky – and this would tell them which way was up. With the introduction of other, human-made sources of illumination, the insects become trapped in a loop, sometimes flying upside down and occasionally causing an insect to crash. The scientists suggest that the moths are not attracted to artificial lights but trapped by them, similar to being caught in a net.

▲ **Some bat species like to hunt by moonlight, but others are 'lunar phobic'**

Bats

While bats are famous for their echolocating skills and are known to use visual and olfactory cues when hunting or navigating, some bats have also been found to use polarised light. The polarisation patterns from the Sun can still be seen after dusk and bats in research studies were able to use the patterns to orient themselves. However, scientists are unsure how the bats are actually able to detect the polarisation.

Other studies have examined whether the way bats hunt is impacted by lunar phases, as it's long been thought that they might have 'lunar phobia', where they decrease their activity due to potential predation risk. However, it seems to vary between different species; one study compared five species and found that one reduced foraging in moonlight, two increased it and two were unaffected. Another study found that bats changed the habitat where they were hunting.

Indigo buntings

The indigo bunting, so-named for the beautifully vibrant colours of the male bird sporting his breeding plumage, was one of the key species featured in 1960s studies to prove that birds migrating at night used stars to help orient themselves.

One of the main studies involved captive wild birds kept in a planetarium, where the display of the celestial skies could be manipulated by the scientists. When the display was flipped by 180°, the birds reoriented themselves to face the right direction to prepare for migration – facing south ready for the autumn migration or north for the spring migration.

Night-migrating indigo buntings are steered by starlight

Eels use the Moon and magnetism to guide their mammoth treks

European eels

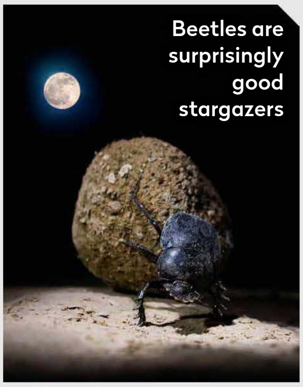
Once hypothesised by the philosopher Aristotle to spontaneously spawn from mud, eels have long been a mysterious animal to humans. In 1922, it was discovered that they breed in the Sargasso Sea and their larvae gradually drift back towards Europe over a couple of years. They then become glass eels and return to European rivers to mature. One study found that in the open ocean the larvae swim more deeply during the full Moon, while other research found that glass eels heading back to the rivers use the Moon's position to orient themselves at sea and are likely also using a variety of other senses to find their way, including the Earth's magnetic field and olfactory cues.

Harbour seals

Seals in tests swam towards certain stars

Scientists have discovered that seals can recognise stars inside a modified planetarium. In an experiment, two harbour seals were placed in a five-metre round pool beneath a dome simulating the Northern Hemisphere's night sky. Researchers used a laser pointer to highlight a star, training the seals to swim towards it for a reward. Later, they changed the dome's orientation and removed the laser, yet the seals still swam towards the correct star. This suggests harbour seals naturally recognise star patterns and may use celestial navigation in the wild.

Dung beetles



Beetles are surprisingly good stargazers

A study published in 2013 provided evidence of an amazing behaviour exhibited by dung beetles. Earlier studies had shown that nocturnal dung beetles were able to use light from the Moon to orient themselves. In this new study, scientists found that even on clear moonless nights the beetles were still rolling their dung in straight lines.

Further experiments conducted in the Johannesburg planetarium, where the night-sky display could be manipulated, showed the beetles continuing to roll their balls in straight lines using starlight but even doing so if only the Milky Way and no other regions of starry sky were shown – the first time this behaviour had been found in any animals.

Even very dim moonlight helps night-wandering ants find their way home

Bull ants

Bull ants have been known to use the sunlight of evening and morning twilight for navigation. However, some are known to leave the nest in the nighttime and find their way safely back to it. How?

Researchers used a polarisation filter to show that these ants were using moonlight, which is visible to them even on cloudy nights, to follow a course back home. This is the first time any animal has been shown to use the dim polarisation pattern produced by the Moon for homing and only the second evidence – after the dung beetles – of it being used for orientation in animals.

Megan Shersby is a naturalist and science writer. She works part time for a wildlife charity and is the lead author of *Where to Watch Wildlife in Britain: Low Carbon* (Bloomsbury, 2026)

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16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

MAY 2025

MARS IN THE BEEHIVE

The Red Planet passes in front of the Beehive Cluster M44 this month

DAYTIME ASTRONOMY

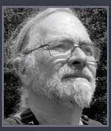
Can you spot Regulus, Venus and Mars in daylight?

STRANGE GALAXIES

Fascinating ellipticals to find in the Bowl of Virgo

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Eta Aquariid meteor shower peak
- ✦ Enormous lunar crater Grimaldi
- ✦ See a micro-Moon on 12 May

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

MAY HIGHLIGHTS

Your guide to the night sky this month

Thursday ▶

1 During the middle of the year, the sky fails to get properly dark. Observing at the start of May still allows most of us to experience truly dark skies and beautiful views of objects such as M13, the Great Globular in Hercules.

Friday

2 Minor planet 4 Vesta reaches opposition, shining at mag. +5.7 among the stars of northern Libra (see page 47). As with all minor planets, through a telescope Vesta simply resembles a star!

Monday

5 See the Lunar X and V clair-obscur effects at around 01:15 BST (00:15 UT).

At 19:00 BST (18:00 UT), mag. +1.3 Regulus (Alpha (α) Leonis) is 1.5° south of a 62%-lit Moon, a perfect chance to find the star in daylight.

Tuesday

6 This morning sees the peak of the annual Eta Aquariid meteor shower, which has a maximum ZHR of 40 meteors per hour. However, the shower is hard to observe well from the UK due to the radiant's low altitude at dawn.

Monday

12 The Moon is full at 17:57 BST (16:57 UT), one day, 16 hours and eight minutes after it reached apogee (its furthest point from Earth). Informally known as a micro-Moon, this full Moon will be slightly fainter and smaller than average.

Wednesday

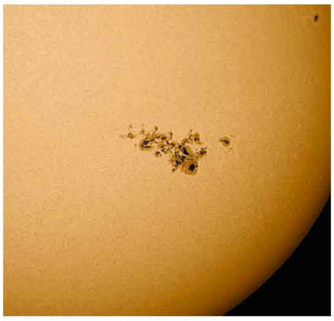
14 Today at 02:40 BST (01:40 UT), the 98%-lit waning gibbous Moon lies 0.9° south-southwest of globular cluster M4 and 1.9° southwest of mag. +1.0 red supergiant Antares (Alpha (α) Scorpii).

Thursday

15 An extremely difficult-to-see Titan shadow transit occurs during daylight between 10:31 BST (09:31 UT) and 15:31 BST (14:31 UT) when Saturn sets. The shadow appears to skirt along the northern edge of the planet's rings.

Saturday

17 The Great Globular in Hercules, M13, is often called the best visible from the Northern Hemisphere. However, M5 in Serpens Caput is a worthy challenger and currently well placed around 01:00 BST (00:00 UT) above the southern horizon.



◀ Tuesday

20 With the summer solstice just one month away, it's worth remembering that the current solar cycle is thought to be close to its peak. If you have correctly filtered equipment, there should be plenty of active solar regions to see right now.

Family stargazing

Minor planet Vesta is within easy reach of binoculars this month and offers a slightly challenging but achievable observation for youngsters. The trick to finding it is to use our all-sky chart on page 50 to locate the top star in Libra, Zubeneschamali (Beta (β) Librae). Next, turn to page 47, where our chart shows how Vesta moves throughout May. The task here is to record, either photographically or by sketching, the stars in the area over several clear nights, looking for the one that's moving – that's Vesta.
www.bbc.co.uk/cbeebies/shows/stargazing

Saturday ▶

24 This morning, the brilliant planet Venus appears 4.8° southwest of the 12%-lit waning crescent Moon. See them rising together shortly before 04:00 BST (03:00 UT).

PETE LAWRENCE X 7, MICHAEL KARRER/CCDGUIDE.COM

◀ Sunday

4 Planet Mars appears 1.1° south of the 44%-lit waxing crescent Moon at 01:46 BST (00:46 UT). At this time, Mars will also be 0.8° northwest of the centre of the Beehive Cluster, M44.

Wednesday

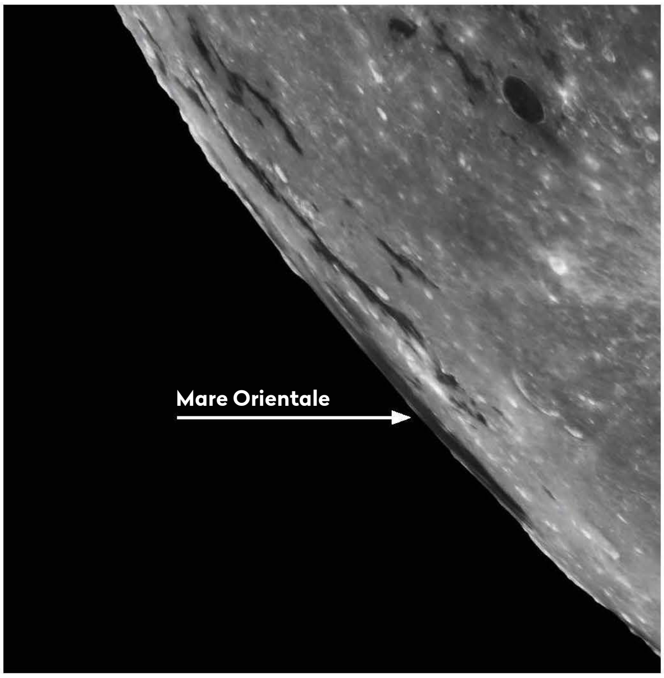
7 If you can locate the 79%-lit waxing gibbous Moon low above the eastern horizon under daylight conditions, binoculars or a small telescope will show that the Jewelled Handle clair-obscur effect is under way.

Saturday ▶

10 If you can catch Venus through a telescope in the morning sky, it's still showing a beautiful crescent phase. Today, it's 35%-lit and 31 arcseconds across. By late May, it will be 49%-lit with a diameter of 24 arcseconds.

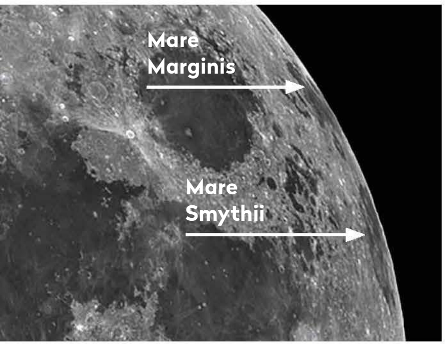
Sunday ▶

18 The lunar libration feature known as Mare Orientale is reasonably favourably positioned for viewing in the morning skies from now until 24 May.



◀ Friday

23 Late May is typically when noctilucent cloud displays start to become visible in the Northern Hemisphere. Last year had some excellent examples. Will 2025 follow suit?



◀ Friday

30 Lunar libration currently favours the eastern part of the Moon, bringing into view features such as 360km-wide Mare Marginis and 200km-wide Mare Smythii.

Saturday

31 Another extremely tricky-to-see Titan shadow transit occurs during daylight hours, between 19:48 BST (18:48 UT) and 14:35 BST (13:35 UT) when Saturn sets. Again, the shadow appears to skirt along the northern edge of the planet's rings.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

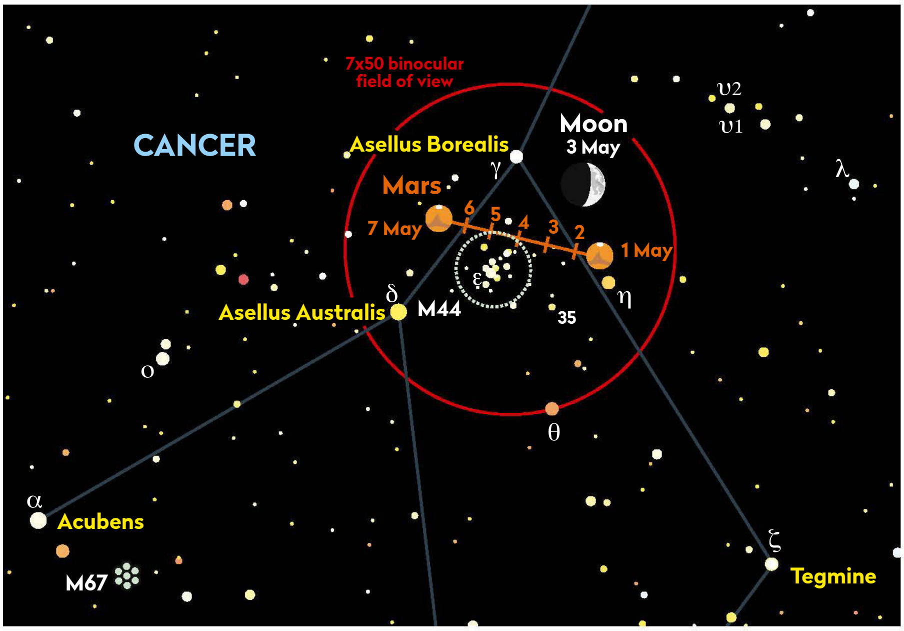
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

THE BIG THREE The top sights to observe or image this month

DON'T MISS

Mars crosses the Beehive

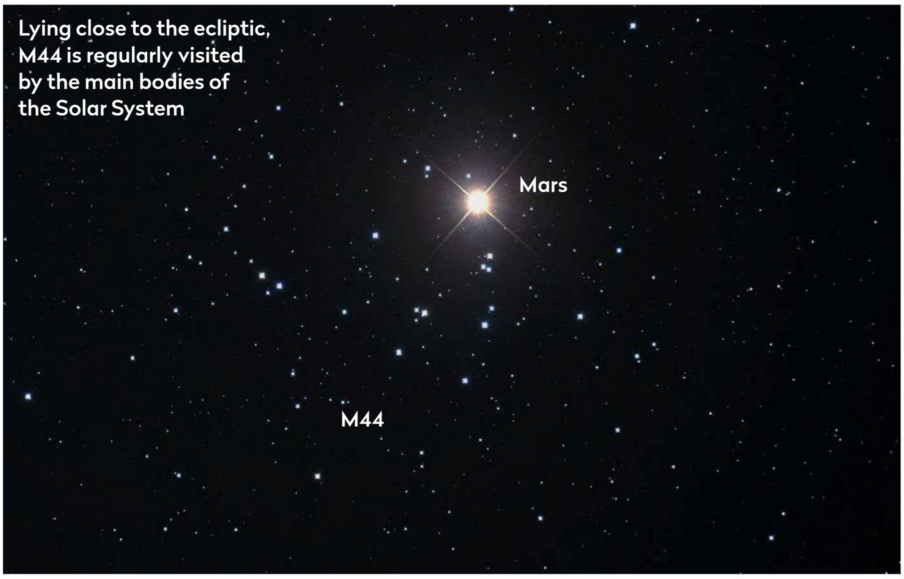
BEST TIME TO SEE: 1–9 May



▲ Mars passes through the northern outskirts of the Beehive Cluster early in the month

The Beehive Cluster, M44, in Cancer sits just 1.5° north of the ecliptic, which means it's in a prime position for conjunctions with Solar System objects such as the Moon, main planets and minor planets. This month, the planet Mars makes a pass through the northern reaches of the cluster, creating a wonderful opportunity to photograph it in the act or, if the weather cooperates, to capture its passage towards, across and past the cluster's stars.

Mars is just coming off its last opposition, which occurred on 16 January.



Lying close to the ecliptic, M44 is regularly visited by the main bodies of the Solar System

ALL PICTURES: PETE LAWRENCE

Mars reaches opposition once every 2.1 years and around this time the planet brightens noticeably and, through the eyepiece of a telescope, appears to grow in apparent size quite markedly. Unfortunately, we're now past the large apparent size bit of opposition, Mars appearing just 6 arcseconds across when it passes across the Beehive.

Despite this, the planet's magnitude, although faded from its opposition peak, still sits around first magnitude and, combined with its strong salmon-pink colour, it will stand out really well. Certainly, its brightness will elevate it well above any of the individual stars in the Beehive itself, the brightest of which is Epsilon (ε) which shines at mag. +6.3.

As we start the month, Mars is located 2° west and 50 arcminutes north of M44's centre. Over subsequent days, the planet moves steadily eastwards, sitting on the edge of the cluster's outer boundary late evening on 2 May.

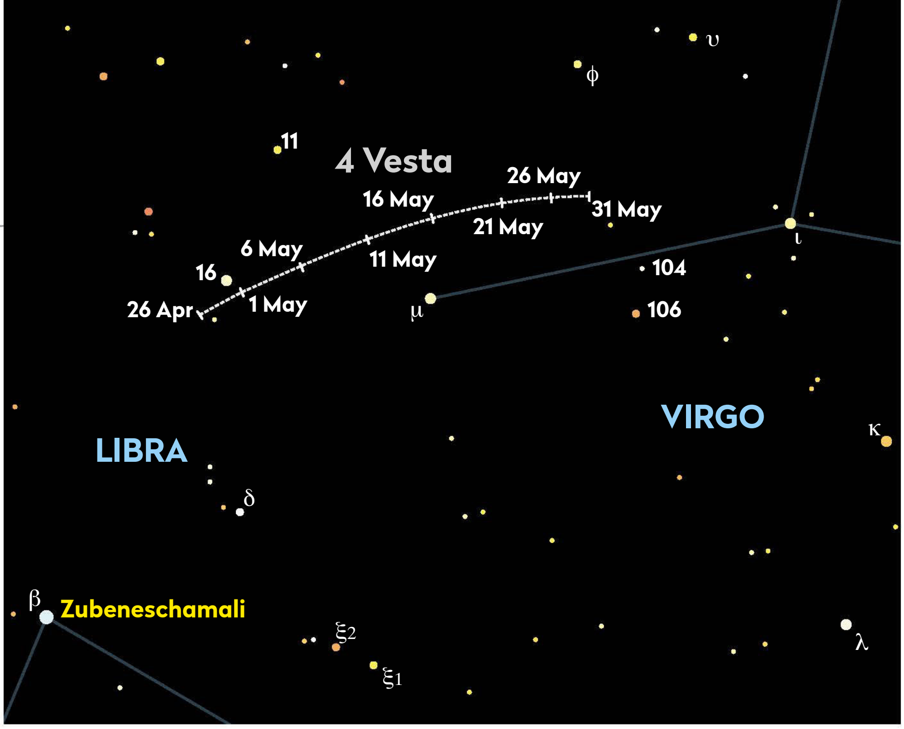
On the evening of 3 May, Mars sits 54 arcminutes northwest of M44's centre and is joined by a 43%-lit waxing crescent Moon 1.8° to the northwest. The Moon moves east at a faster rate than the planet and by the early hours of 4 May sits a fraction over a degree north of Mars. Find them low over the west-northwest horizon around 01:30 BST (00:30 UT).

In the late evening on 4 May, Mars will be as close as it gets (this time around) to the centre of the cluster, located 0.6° to the north of this position. This creates an ideal photo opportunity, the Red Planet perfectly posed just to the north of the cluster's core.

In terms of viewing visually, a low-power instrument such as binoculars or a small telescope using a low-power eyepiece is the way to go. If you pile on too much power to, for example, reveal Mars's tiny disc, you'll be looking right through the centre of the cluster, losing the impact of the arrangement.

Vesta at opposition

BEST TIME TO SEE: 1–4 May after moonset. Vesta is visible all month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4 Vesta
26 May
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▲ From a dark site, you may be able to see mag. +5.7 Vesta with the naked eye

Minor planet 4 Vesta reaches opposition on 2 May, a time when it will be shining at mag. +5.7 among the stars of northern Libra. This offers up an interesting opportunity to try to spot Vesta with the naked eye if you have access to a dark-sky site.

Vesta was the fourth minor planet discovered and is the brightest, able to reach a peak mag. of +5.1 during an extremely favourable opposition. The average threshold of naked-eye visibility from a dark sky site is mag. +6.0, but it doesn't take much in the way of light pollution or haze to raise this threshold.

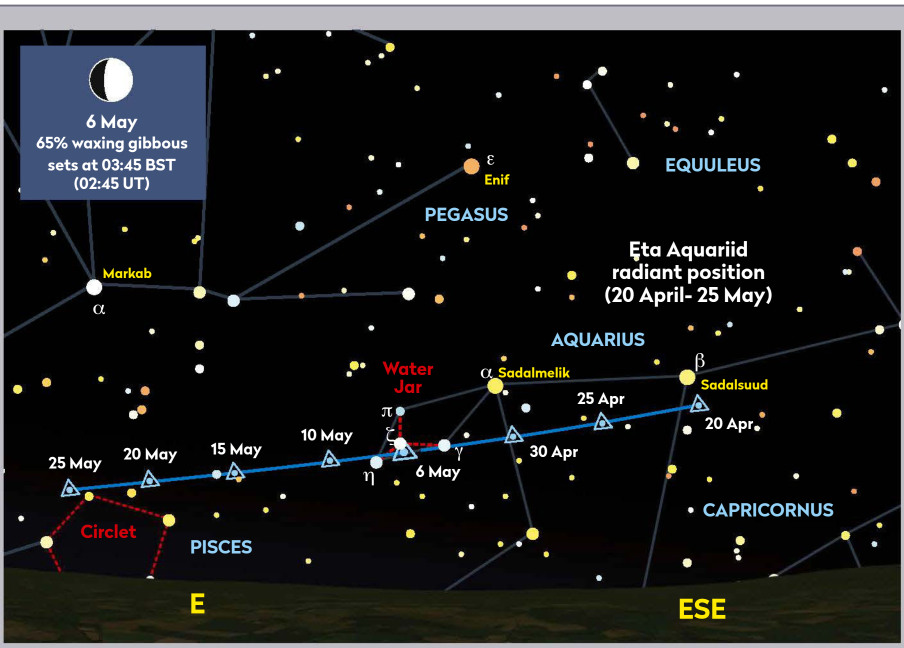
Consequently, seeing Vesta with the naked eye may be a step too far for many this year, the easiest observing option being binoculars. Here, things get a lot easier as Vesta will be visible through any binocular size. It also goes without saying that a small or larger telescope will easily be able to bring you a view of Vesta.

To locate Vesta using binoculars, wait for the sky to darken and then try to work out the form of Virgo. This is easier said than done, as the constellation is quite sprawling in nature. Find the three stars Iota (ι) and Mu (μ) Virginis together with 16 Librae, magnitudes +4.1, +3.8 and +4.5, respectively. During May, Vesta follows an arcing path from 16 Librae to 1° north of the mid-point between Iota and Mu Virginis. From 16 Librae to Mu Virginis is around 3.8°, which fits easily inside an average binocular field of view.

If you have very dark skies, then once you've located Vesta with binoculars, try for it with the naked eye but make sure your eyes are properly dark-adapted; 20 minutes in complete darkness should get your eyes to peak sensitivity.

Eta Aquariids

BEST TIME TO SEE: Early hours of 6 May before dawn


6 May
65% waxing gibbous
sets at 03:45 BST
(02:45 UT)
ε
Enif
EQUULEUS
PEGASUS
Markab
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Eta Aquariid
radiant position
(20 April- 25 May)
AQUARIUS
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20 Apr
ζ
10 May
γ
30 Apr
25 May
20 May
15 May
η
6 May
Circlet
PISCES
CAPRICORNUS
E
ESE

▲ Despite its decent maximum zenithal hourly rate of 40 meteors per hour, the Eta Aquariid meteor shower is tricky to observe well from the UK

The Eta (η) Aquariid meteor shower is expected to reach its peak around 04:00 BST (03:00 UT) on 6 May. The shower is active between 19 April and 28 May and has a respectable peak ZHR of 40 meteors per hour. However, this is a difficult shower to observe from the UK because the radiant barely gains much altitude before dawn kicks in. So, take the 40 meteors per hour figure with a pinch of salt – the actual number of meteors seen will be far less.

There will be a little moonlight interference this year, the 65%-lit waxing gibbous Moon setting around 03:45 BST (02:45 UT) on 6 May. Moonset occurs in the opposite direction to where the radiant is rising, so the view to, say, the south, shouldn't take too much of a hit from the very low Moon.

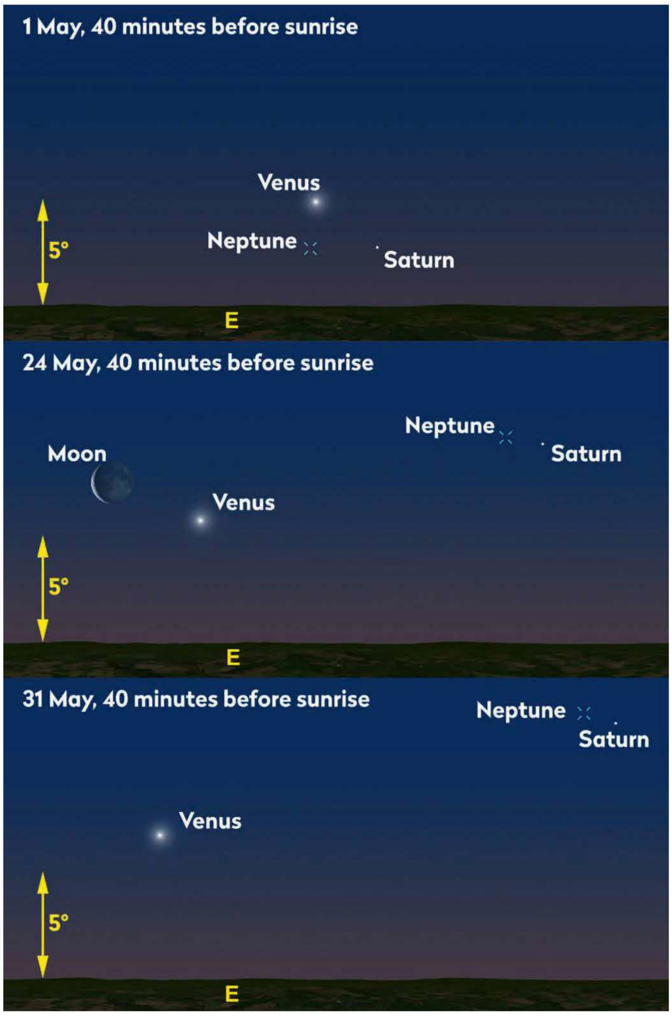
The Eta Aquariids is one of two showers to result from Earth passing through the debris of comet 1P/Halley (Halley's Comet), the other being the Orionids which peaks around 21 October. From the centre of the UK, the Eta Aquariid radiant will have barely risen as astronomical darkness comes to an end around 02:50 BST (01:50 UT).

THE PLANETS

Our celestial neighbourhood in May

PICK OF THE MONTH

▶ Venus's position before sunrise this month, including a lovely encounter with a crescent Moon on 24 May


1 May, 40 minutes before sunrise
Venus
Neptune
Saturn
5°
E
24 May, 40 minutes before sunrise
Neptune
Saturn
Moon
Venus
5°
E
31 May, 40 minutes before sunrise
Neptune
Saturn
Venus
5°
E

PETE LAWRENCE X 2

Venus

Best time to see: 31 May, 40 minutes before sunrise
Altitude: 7° (low)
Location: Pisces
Direction: East
Features: Phase, subtle atmospheric shading
Recommended equipment: 75mm scope or larger

Beautiful Venus is a morning planet and, due to a low angle between the ecliptic and the eastern horizon at dawn, isn't particularly well positioned. Despite this, the loss of main planets near to the Sun means that it's the best planetary prospect right now.

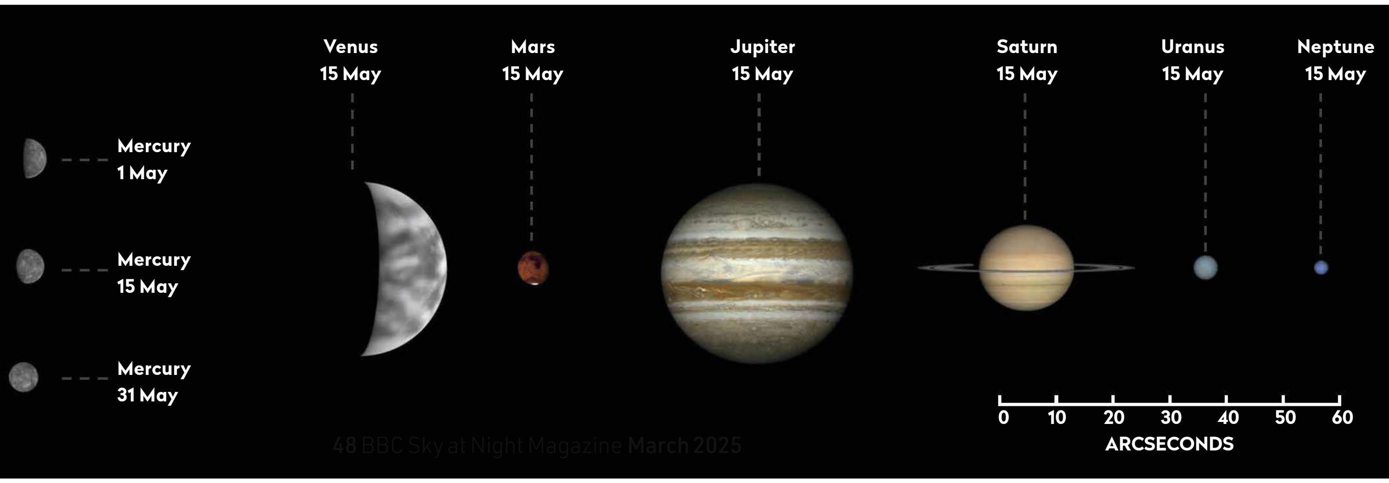
Venus rises 75 minutes before the Sun on 1 May. Shining at mag. –4.4, if you can get a telescope on it, you'll see it's currently showing a 29%-lit crescent phase with an apparent diameter of 36 arcseconds. At the beginning of May, it sits close to the planet Saturn, separated by 3.9° on 1 May. At mag. +0.8, Saturn will be difficult to spot without the use of binoculars. Neptune is in there too, 3.3° northeast of Saturn, but at mag. +7.9 will be very tricky to spot against the bright dawn.

As the month progresses, the altitude of Venus before sunrise deteriorates, making it harder to get a good view. On 24 May, a 12%-lit waning crescent Moon sits 4.8° northeast of Venus in the morning twilight. Despite the lack of true darkness for this encounter, given a good flat eastern horizon the pair should look quite stunning together. The best views will be had from around 04:00 BST (03:00 UT) onwards.

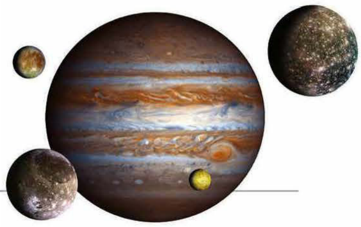
By the end of the month, Venus actually manages to increase the gap between it rising and the Sun rising to 90 minutes, but its altitude is just over 12° at the time the Sun's disc is making an appearance. On 31 May, its brightness will have dropped a fraction to mag. –4.2 and through a telescope its phase will have increased to 49%-illuminated. Its apparent diameter continues to reduce throughout the month and on 31 May, Venus appears 24 arcseconds across.

The planets in May

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 May
Mars
15 May
Jupiter
15 May
Saturn
15 May
Uranus
15 May
Neptune
15 May
Mercury
1 May
Mercury
15 May
Mercury
31 May
0
10
20
30
40
50
60
ARCSECONDS

48 BBC Sky at Night Magazine March 2025



Mercury

Like its inner Solar System neighbour Venus, Mercury is also currently a morning planet, but positioned too low to really be seen properly from the UK in the dawn twilight. Mercury lines up with the Sun on the opposite side of its orbit from Earth to reach superior solar conjunction on 30 May.

Mars

Best time to see: 1 May, from 22:00 BST (21:00 UT)
Altitude: 43°
Location: Cancer
Direction: Southwest

Mars is located just 1.6° to the west of M44, the Beehive Cluster in Cancer on 1 May, the planet passing through the northern regions of the cluster over the following evenings. On 4 May, magnitude +1.0 Mars sits 23 arcminutes north of the cluster's centre. Time is running out for the Red Planet, though, mag. +1.3 Mars appearing just 14° above the western horizon by the end of May.

Jupiter

Best time to see: 1 May, from 22:00 BST (21:00 UT)
Altitude: 17°
Location: Taurus
Direction: West-northwest

The current observational window for the planet Jupiter closes this month, the planet moving into the Sun's glare at the end of May. On 1 May, Jupiter can still be seen languishing between the tips of the 'horns' of Taurus the Bull, low over the west-northwest horizon as twilight begins to darken.

Shining at mag. –1.8, through the eyepiece of a telescope Jupiter has an apparent diameter of 33 arcseconds. A 22%-lit waxing crescent Moon sits 17° east-northeast of the planet on 1 May.

By the middle of the month, as it passes just 1.1° north of M1 the Crab Nebula, twilight will take its toll and it will no longer be possible to see Jupiter against a dark sky from the UK. The Moon catches up with the planet again on 28 May, a 4%-lit waxing lunar crescent located 6.2° northeast of Jupiter on this date, although low altitude will unfortunately hamper this view.

Saturn

Best time to see: 31 May, from 03:30 BST (02:30 UT)
Altitude: 6°
Location: Pisces
Direction: East

Saturn is another morning planet struggling to escape from the Sun's glare. As it manages to do this at the end of the month, a shallow dawn ecliptic angle keeps it at low altitude before sunrise. The planet is in a small triangle with Venus and Neptune at the start of the month. A 21%-lit waning crescent Moon is positioned 7° northeast of Saturn on the morning of 23 May, nestled between Saturn and Venus.

Uranus

Uranus is unobservable this month and for the coming weeks as the planet reaches solar conjunction on 18 May.

Neptune

Neptune currently sits close to Saturn in the morning twilight, but the planet's low altitude and a bright sky will keep it hidden from view.

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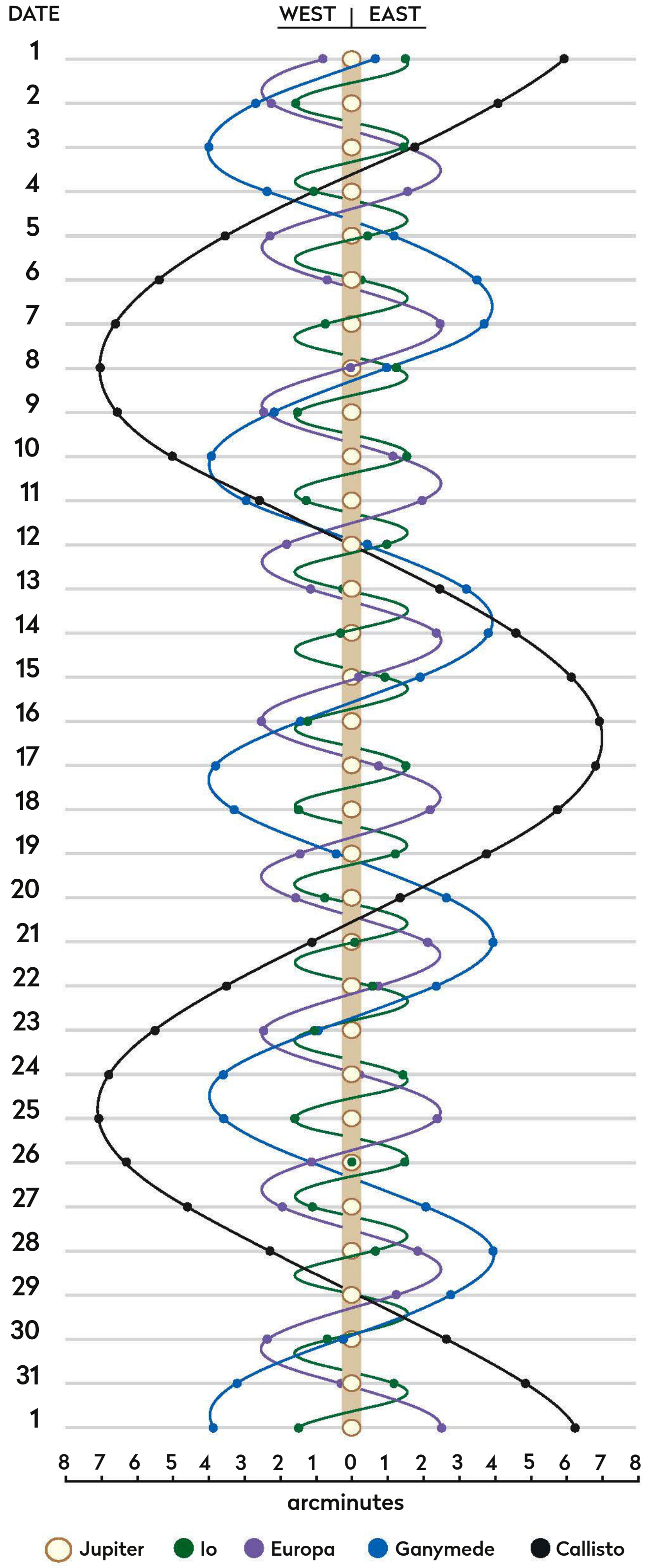
JUPITER'S MOONS: MAY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – MAY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

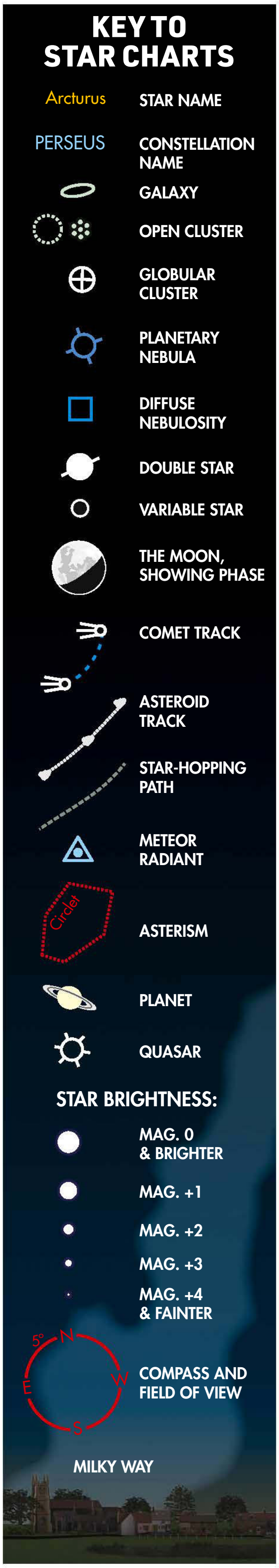

KEY TO STAR CHARTS
Arcturus
STAR NAME
PERSEUS
CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON, SHOWING PHASE
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet
ASTERISM
PLANET
QUASAR
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER
5°
N
E
W
S
COMPASS AND FIELD OF VIEW
MILKY WAY

CHART: PETE LAWRENCE

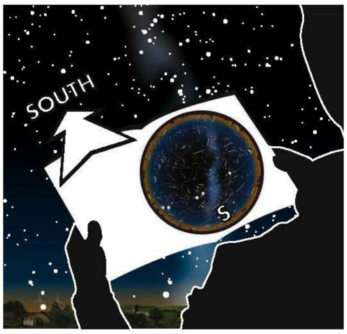
When to use this chart

1 May at 01:00 BST
15 May at 00:00 BST
31 May at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in May*

Date	Sunrise	Sunset
1 May 2025	05:35 BST	20:40 BST
9 May 2025	05:19 BST	20:54 BST
17 May 2025	05:06 BST	21:07 BST
25 May 2025	04:55 BST	21:19 BST

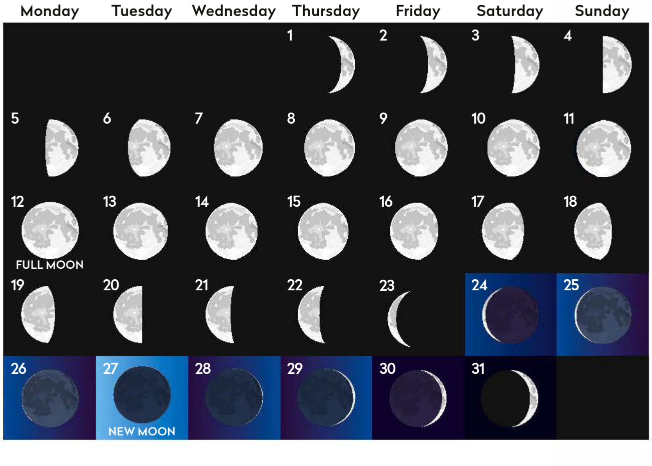
Moonrise in May*

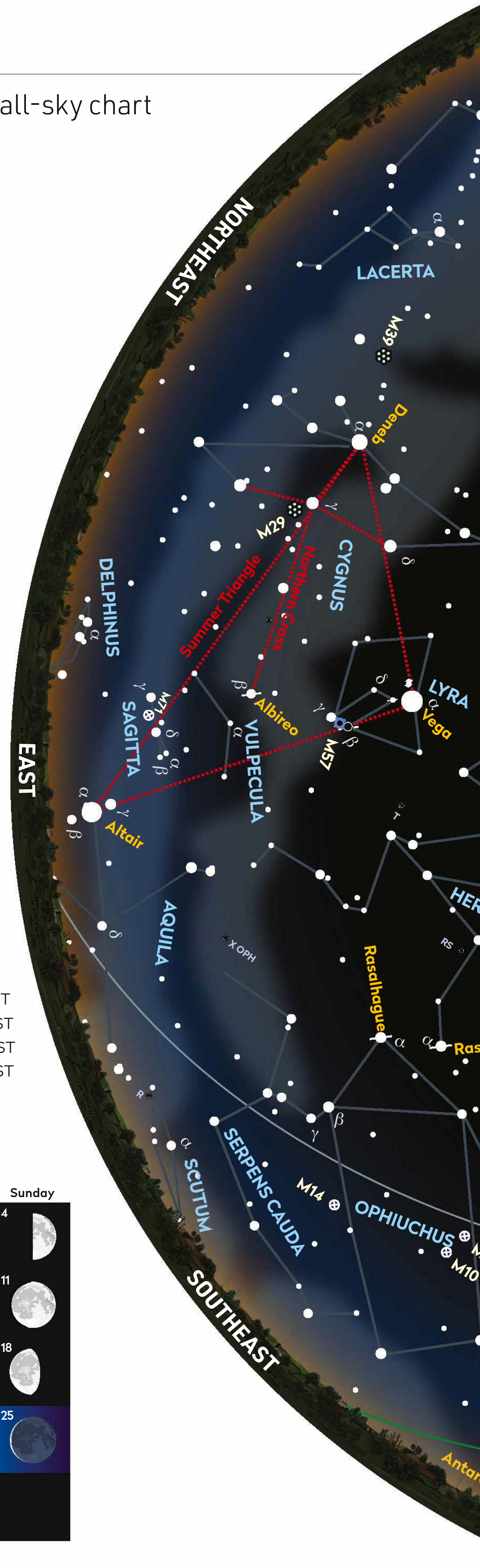
Moonrise times

1 May 2025, 07:22 BST
5 May 2025, 12:45 BST
9 May 2025, 17:42 BST
13 May 2025, 22:44 BST
17 May 2025, 01:35 BST
21 May 2025, 02:50 BST
25 May 2025, 03:34 BST
29 May 2025, 06:10 BST

*Times correct for the centre of the UK

Lunar phases in May


Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
1
2
3
4
5
6
7
8
9
10
11
12
FULL MOON
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
NEW MOON
28
29
30
31


NORTHEAST
LACERTA
M39
Deneb
M29
CYGNUS
Northern Cross
Summer Triangle
DELPHINUS
LYRA
Vega
M57
Albireo
VULPECULA
M71
SAGITTA
EAST
Altair
AQUILA
X OPH
HER
RS
Rasalhague
Ras
R
SCUTUM
SERPENS CAUDA
M14
OPHIUCHUS
M10
SOUTHEAST
Antar

FREE BONUS CONTENT

Paul and Pete's night-sky highlights

Southern Hemisphere guide

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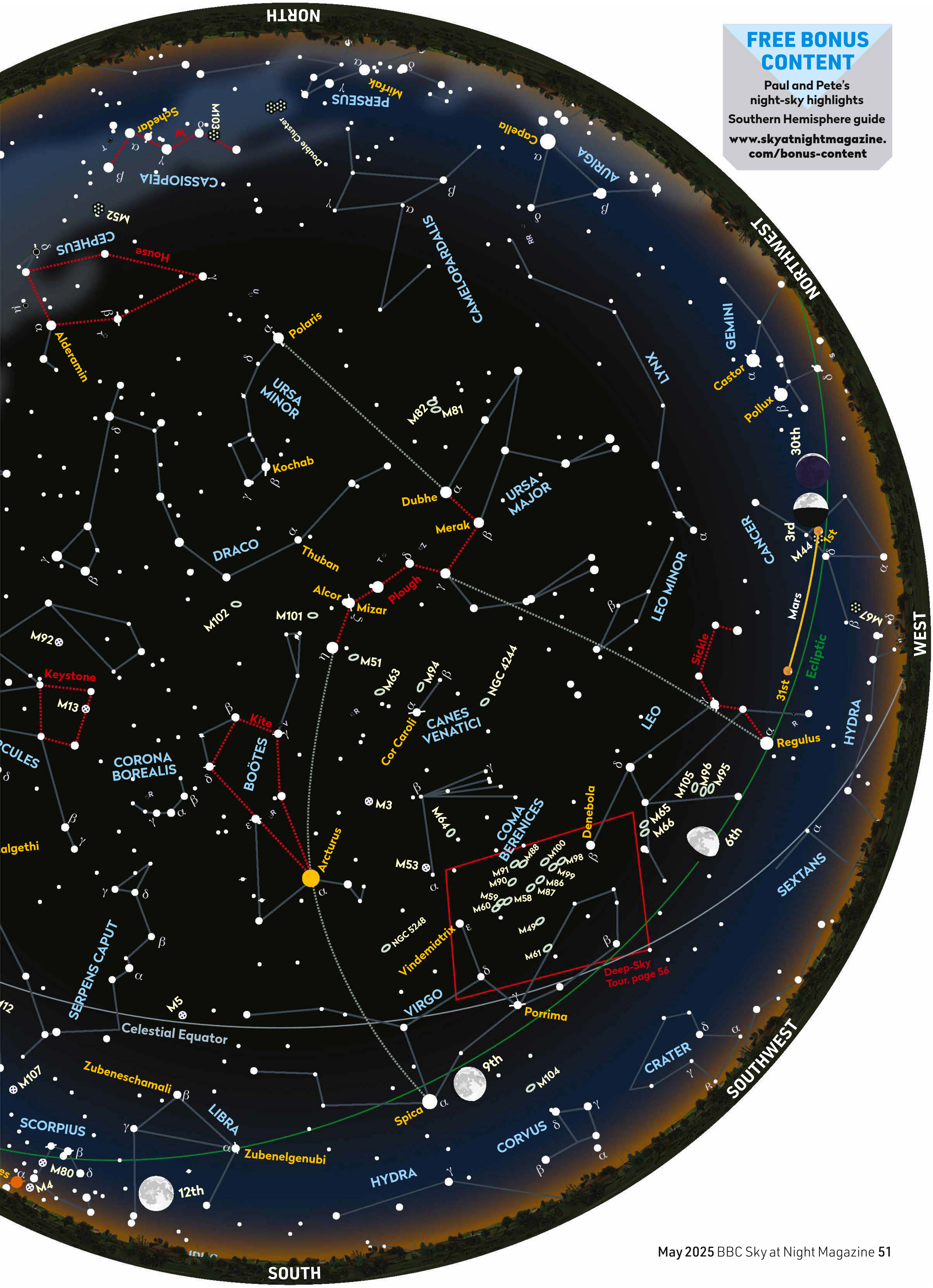
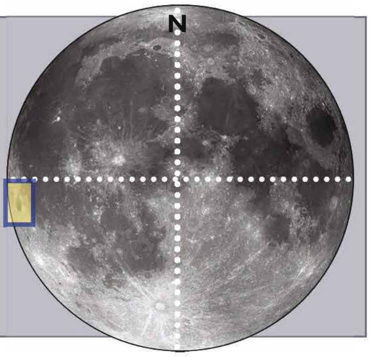

NORTH
PERSEUS
Mirfak
Double Cluster
CASSIOPEIA
Schedar
W
M103
Capella
AURIGA
M52
CEPHEUS
House
Alderamin
CAMELOPARDALIS
Polaris
URSA MINOR
Kochab
NORTHWEST
GEMINI
Castor
Pollux
LYNX
30th
M82
M81
Dubhe
URSA MAJOR
Merak
DRACO
Thuban
3rd
1st
CANCER
M44
LEO MINOR
Alcor
Mizar
Plough
M102
M101
M51
Mars
M67
WEST
M92
Keystone
M13
HERCULES
M63
M94
NGC 4244
Sickle
Ecliptic
31st
CANES VENATICI
Cor Caroli
LEO
Kite
BOÖTES
CORONA BOREALIS
Regulus
HYDRA
M3
M105
M96
M95
Denebola
COMA BERENICES
M64
M65
M66
6th
Rasalgethi
Arcturus
M53
M88
M100
M91
M98
M90
M99
M86
M59
M58
M87
M60
SEXTANS
NGC 5248
M49
Vindemiatrix
M61
SERPENS CAPUT
Deep-Sky Tour, page 56
M5
VIRGO
Porrima
Celestial Equator
M12
SOUTHWEST
9th
M107
Zubeneschamali
M104
CRATER
Spica
LIBRA
SCORPIUS
CORVUS
Zubenelgenubi
M80
Antares
M4
12th
HYDRA
SOUTH

MOONWATCH May's top lunar feature to observe

Grimaldi

Type: Crater
Size: 226km
Longitude/latitude: 68.4° W, 5.4° S
Age: Older than 3.9 billion years
Best time to see: Six days after first quarter (10 and 11 May) or five days after last quarter (24 and 25 May)
Minimum equipment: 10x binoculars



Grimaldi is an immense, lava-filled crater located on the western side of the Moon, close enough to the limb to be affected by libration, the apparent rocking and rolling action caused by the Moon's elliptical and tilted orbit. Under poor libration, Grimaldi appears very close to the Moon's limb, foreshortened into a narrow ellipse. Under favourable libration, it appears well inside the Moon's peripheral edge and shows plenty of highland features between it and the limb. At such times, it looks like a wide oval.

With a diameter of 226km and a floor filled with flat, dark lava, Grimaldi stands out extremely well from its bright highland surroundings. This is a good thing because being an ancient feature, Grimaldi's rim hasn't fared well. It's so worn by subsequent impacts that it no longer resembles what you'd consider to be a typical crater rim, rather appearing as a wide annulus of hills, lumps, cracks and smaller craterlets. Its floor is its saving grace, turning Grimaldi into an easily identified navigational marker west of 700km x 500km **Oceanus Procellarum**. Had its floor not been totally filled with dark lava, Grimaldi would appear more like neighbouring 146km **Riccioli**. Located immediately northwest of Grimaldi, Riccioli's floor is only partially filled with lava. Of similar age to Grimaldi, Riccioli's rim and most of its floor are heavily eroded, making it harder to recognise as a result.

> ***Grimaldi stands out extremely well from its bright highland surroundings***

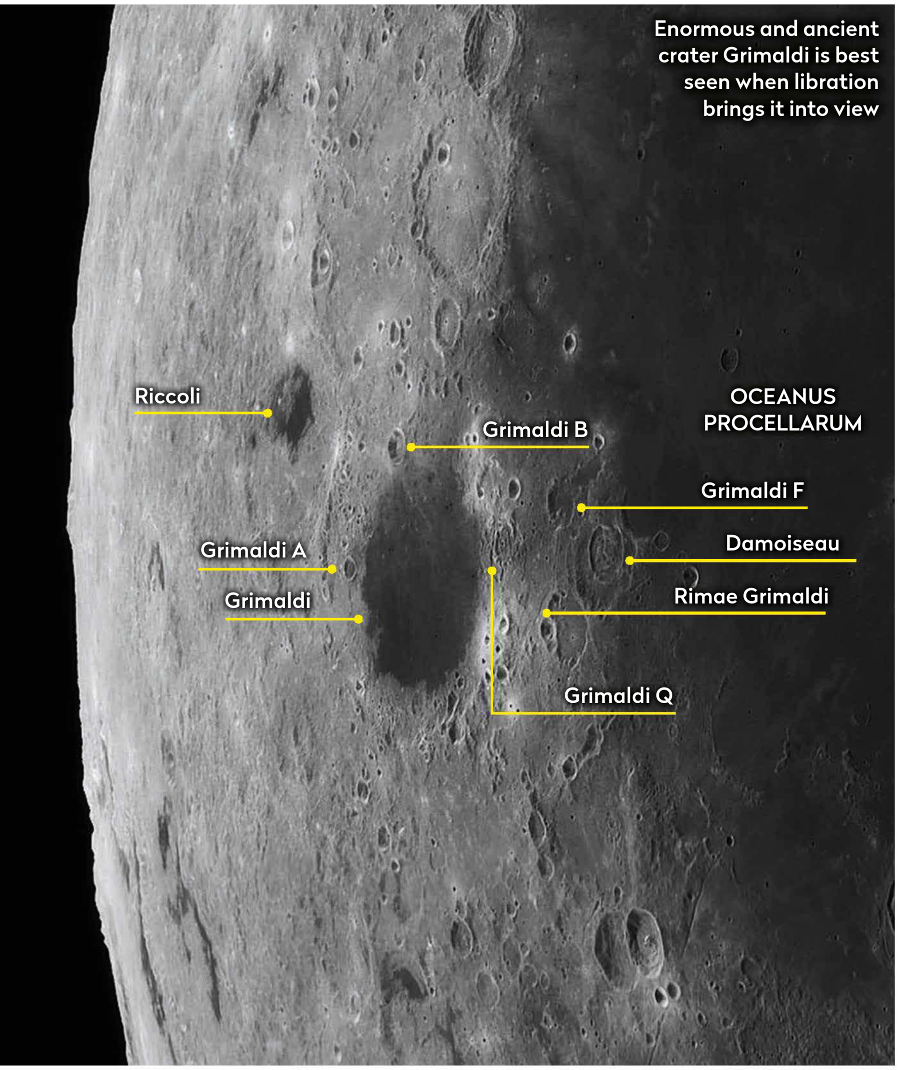
Grimaldi's outer rim, or what you can judge to be its outer rim, is around 226km in diameter, the inner dark lava floor appearing 142km across. A quick bit of maths indicates that the more or less evenly thick battered edge annulus is 42km wide. This feature is now regarded as a two-ring structure – inner and outer – the crater now being referred to as the Grimaldi Basin. The dark inner floor has an area double that of Wales.

In the southeast section of the rough surrounding region, peaks rise to heights over 3km above Grimaldi's floor. To the east of this outer section run a series of rilles known as **Rimae Grimaldi**. They extend for around 230km but are narrow, being only 2km wide. Consequently, a 300mm or larger scope is required to see them. To the east of the rilles and on the shore of Oceanus Procellarum is 34km **Damoiseau**, a sharp-rimmed crater with an exquisitely detailed rough inner floor.

Northwest of crater Damoiseau is the broken form of 29km **Grimaldi F**, Rimae Grimaldi passing south to north across the floor of this crater. The northeast rim of Grimaldi F is broken and leads to a pronounced gap in the rough highlands, a flat-surfaced channel connecting Grimaldi F to the surface of Oceanus Procellarum.

The eastern section of the basin is marked by 25km **Grimaldi Q**, a complex feature to identify that is surrounded by rough, raised massifs separated by deep grooves. To the north is 20km x 22km **Grimaldi B**, a sharp-edged crater, the largest within the basin's borders. To the west is 15km **Grimaldi A**, another sharp crater with a flat inner floor.

PETE LAWRENCE X 3



Enormous and ancient crater Grimaldi is best seen when libration brings it into view

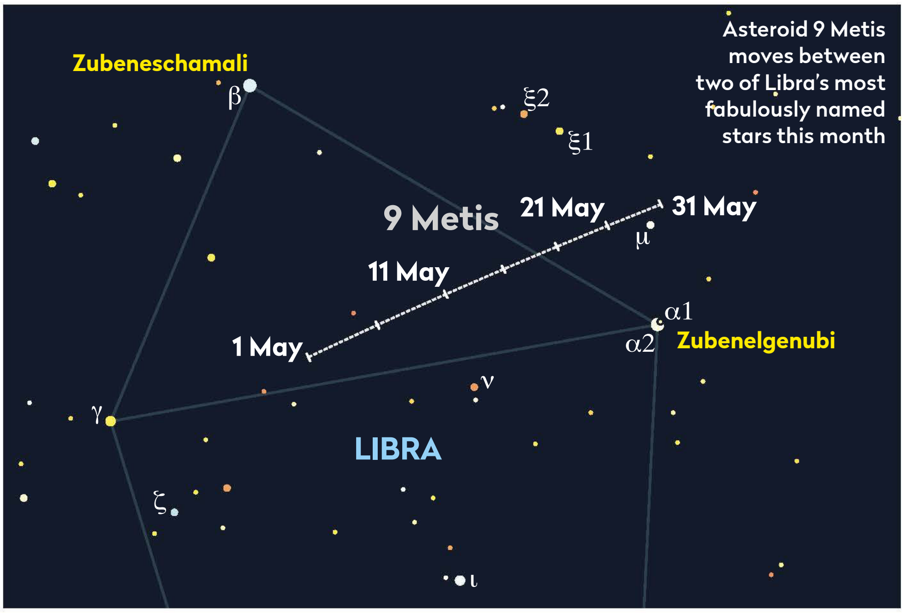
COMETS AND ASTEROIDS

Use a small scope to track minor planet 9 Metis

Minor planet 9 Metis reaches opposition on 8 May when it can be found moving through the stars of Libra. Throughout much of the month it'll be contained within the triangle defined by mag. +2.8 Zubenelgenubi (Alpha (α) Librae), mag. +2.6 Zubeneschamali (Beta (β) Librae) and mag. +3.9 Gamma (γ) Librae, making it fairly easy to locate. At mag. +9.7, it'll be too faint for binoculars but an easy target for a small telescope or smart scope.

On 1 May, Metis is a little north of the point two-fifths of the way along the line from Gamma towards Zubenelgenubi, moving west-northwest to cross the line between Zubenelgenubi and Zubeneschamali on 19/20 May. It starts May shining at mag. +9.9, increasing marginally to mag. +9.7 at opposition before dropping slightly to mag. +10.1 at the end of the month.

Metis is a main-belt asteroid, one of many similar objects orbiting within the region between Mars and Jupiter. It's a large siliceous or S-type asteroid, meaning it has a stony, mineralogical composition. Potato-shaped Metis measures roughly 222km x 195km x 140km. Variation in its reflected light suggests that it tapers at one end. It takes 3.69 years to orbit the Sun, its orbital distance ranging from 2.68 AU to 2.10 AU. Metis rotates once relative to the stars every 5.1 hours. It was identified by Irish astronomer Andrew Graham on 25 April 1848.



Asteroid 9 Metis moves between two of Libra's most fabulously named stars this month

STAR OF THE MONTH

Heze, a Virgo star that's moving south

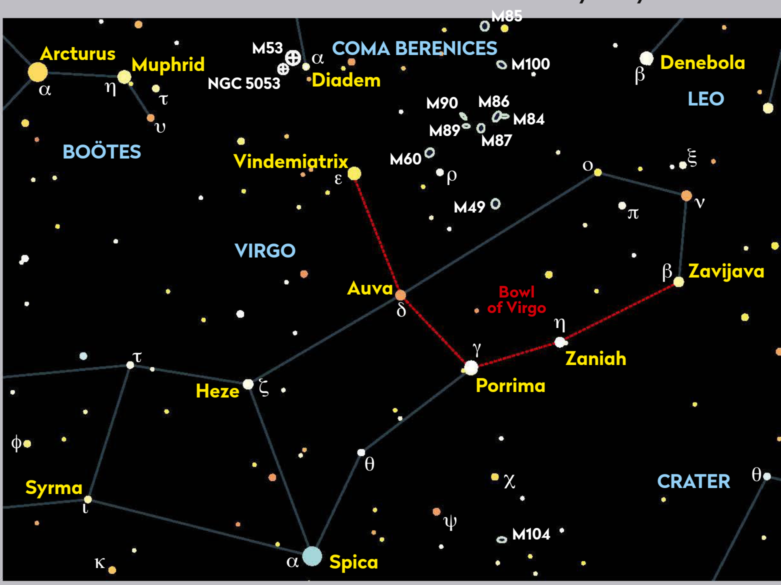
Heze (Zeta (ζ) Virginis) is located 11° north and slightly east of Spica (Alpha (α) Virginis), the quintessential star of spring. Spica shines at mag. +1.00 and is easy to locate with the naked eye. Heze is dimmer at mag. +3.4 but still easy to pick out in all but the most light-polluted skies. It's a binary star 74 lightyears from Earth and its name is unusual in that its origin is unknown, first appearing in a version of *Atlas Coeli*, published in 1951.

Of the two components in the Heze system, it's the brighter one, Zeta Virginis A, that bears the name Heze. The companion, Zeta Virginis B, was only discovered in 2010 and our knowledge about it is incomplete, including an accurate determination of its orbital elements. Current thinking suggests it could be a red dwarf orbiting at a distance at least 29.4 AU from its primary, with a period of 124 years. Zeta Virginis A has a spectral type of A3 V, which indicates it's a dwarf star that shines with a white colour.

It's not dissimilar to the Sun in mass and size, being roughly twice as large in both categories. It's a rapid rotator with a rotational velocity of 222km/s. Our Sun rotates at a more leisurely 2km/s.

Heze currently sits 36 arcminutes south of the celestial equator, but this hasn't always been so. Due to precession, the section of celestial equator near Heze is moving north, creating the impression that the star is moving south by about 18 arcseconds per year.

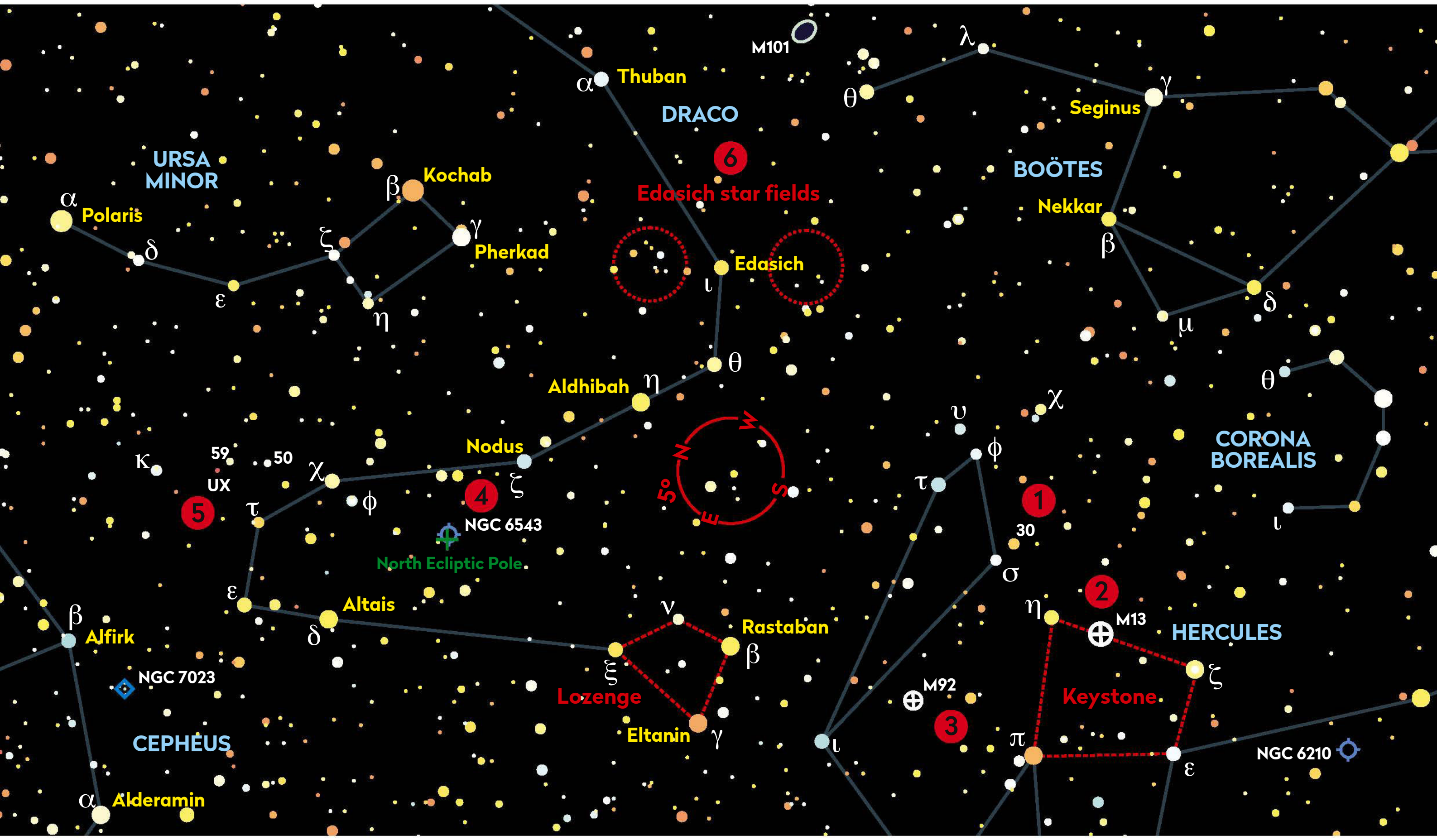
▼ Binary Heze will remain in the southern celestial hemisphere for a few thousand years yet



BINOCULAR TOUR

With Steve Tonkin

Discover full-to-bursting glitter ball clusters and one of the reddest stars you'll see


M101
α
Thuban
DRACO
θ
λ
γ
Seginus
URSA MINOR
α
Polaris
δ
β
Kochab
γ
Pherkad
ζ
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6
Edasich star fields
Edasich
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BOÖTES
Nekkar
β
δ
μ
θ
Aldhibah
η
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CORONA BOREALIS
Nodus
ζ
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NGC 6543
North Ecliptic Pole
κ
59
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M13
HERCULES
ε
Altais
δ
β
Alfirk
NGC 7023
ν
Rastaban
β
ξ
Lozenge
Eltanin
γ
M92
3
Keystone
ζ
π
ε
NGC 6210
ι
CEPHEUS
α
Alderamin

1. 30 Herculis

10x 50 The distinctly orange star 30 Herculis lies 1° to the west-southwest of mag. +4.2 Sigma (σ) Herculis. The magnitude of this semi-regular variable SRb-type star has recently been changing between about mag. +4.4 and mag. +6.3, with a period of 62–89 days between maxima. Despite being a similar mass to the Sun, this red giant has a radius larger than Earth's orbit, giving us an indication of how the Sun will evolve. ☐ **SEEN IT**

2. The Great Globular Cluster in Hercules

10x 50 M13 is called the Great Globular Cluster with good reason and is just visible to the naked eye with averted vision in a dark, transparent sky. Even with small binoculars, this mag. +5.8 cluster can be visible under urban skies, although not nearly as splendidly as it appears in darker conditions. The 400,000 stars that comprise this 145-lightyear-diameter cluster lie about 22,000 lightyears away. ☐ **SEEN IT**

3. M92

15x 70 There are many fine objects that are under-observed because of their proximity to a more famous one. Thanks to M13, globular cluster M92 is one of these. To find it, go two-thirds of the way from mag. +3.5 Eta (η) Herculis to mag. +3.8 Iota (ι) Herculis. M92's 300,000 or so stars are concentrated into an apparent diameter about half that of the Moon. Although not as bright as M13, it handles light pollution quite well. ☐ **SEEN IT**

4. Cat's Eye Nebula

15x 70 The Cat's Eye Nebula, NGC 6543, marks the position of the North Ecliptic Pole, the centre of the circle that the North Celestial Pole makes in its 25,770-year precessionary cycle. It's near the centre of a line joining white mag. +3.2 Aldhibah (Zeta (ζ) Draconis) to yellow mag. +3.1 Altais (Delta (δ) Draconis), appearing like an ethereal green star that winks at you if you change from direct to averted vision. ☐ **SEEN IT**

5. UX Draconis

10x 50 Using the chart, identify the mag. +5.1 star 59 Draconis. With it centred, look 0.75° east where there's a very red star. This is UX Draconis, which varies irregularly by more than a magnitude (from mag. +5.9 to +7.1), with a period of 175 days. But we're here for the colour; carbon in UX Draconis's atmosphere makes it one of the reddest stars anywhere in the night sky. ☐ **SEEN IT**

6. Edasich star fields

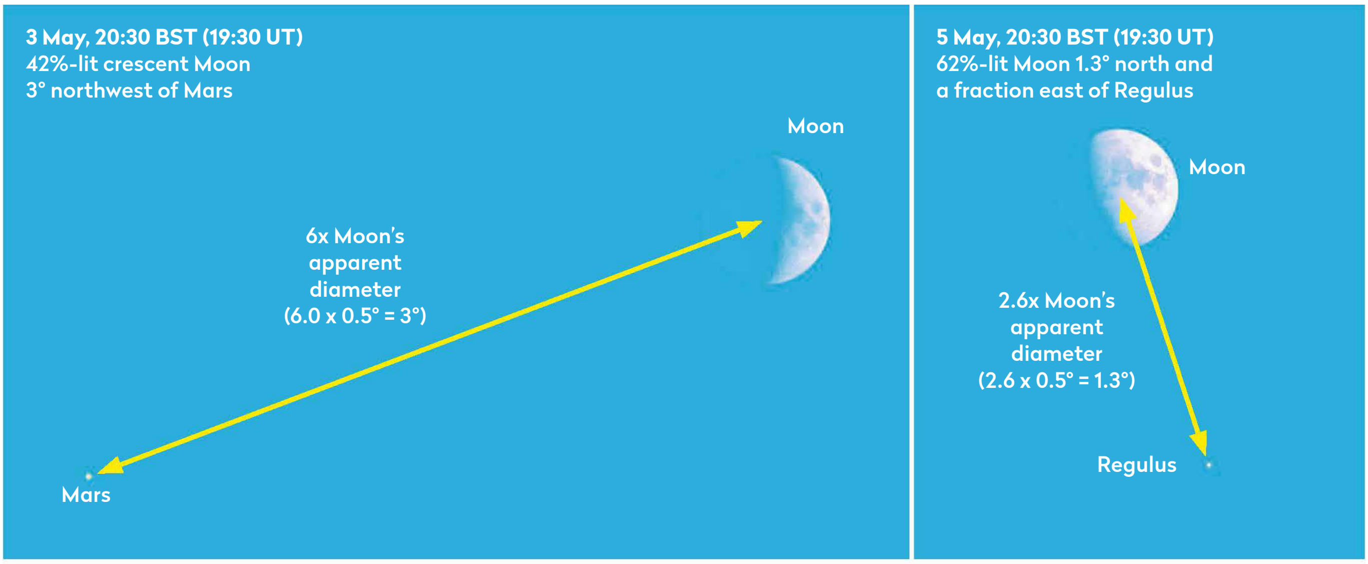
10x 50 Edasich is the name for mag. +3.3 Iota (ι) Draconis. Just to the north of it is a group of mostly sixth- and seventh-magnitude stars (with a sprinkling of fainter ones) that extends for about 3°. To the south lies a slightly sparser group. It's very rewarding to spend time examining them; there are several binocular double and triples, with colour varieties ranging from orange to blue. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Ever done daytime astronomy? See if you can find two planets and a star in daylight


3 May, 20:30 BST (19:30 UT)
42%-lit crescent Moon
3° northwest of Mars

Moon
6x Moon's apparent diameter (6.0 x 0.5° = 3°)
Mars

5 May, 20:30 BST (19:30 UT)
62%-lit Moon 1.3° north and
a fraction east of Regulus

Moon
2.6x Moon's apparent diameter (2.6 x 0.5° = 1.3°)
Regulus

▲ **The Moon pays a close visit to both Regulus and Mars this month, making them potential daytime targets to track down**

Apart from the Sun and Moon, seeing stars and other astronomical targets during the day isn't that common. It's not that bright objects can't be seen – they can. The issue is finding them. In order to see a bright star in the daytime sky, you'll need a bit of optical assistance. Head outside on any clear, crisp day and, let's face it, you won't see any stars apart from the Sun. However, a telescope can reveal the intense, point-source light of a star embedded in a blue daytime sky.

So how do you go about finding nighttime stars in the daytime? A permanently Go-To-enabled mount will do it with a degree of ease. If you have such a setup, give it a try on one of the brighter daytime stars visible at the moment, such as Arcturus, Spica and Regulus. If you don't have such a setup, another method is to use the natural navigational aid provided by the Moon.

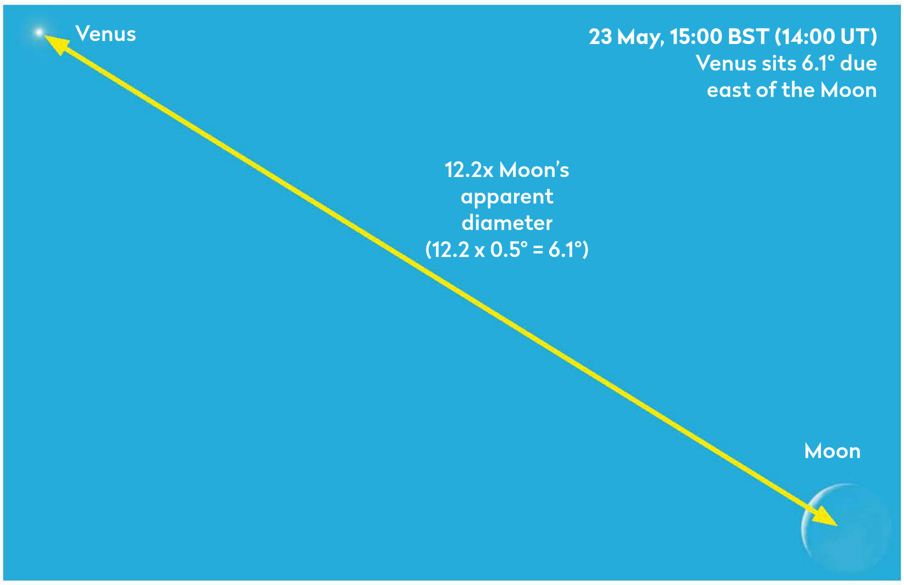
On 2 May, for example, just before sunset the Moon sits near mag. +1.2 Pollux (Beta (β) Geminorum). If the sky is clear, have a go and see whether you can spot Pollux; the 31%-lit waxing crescent Moon will be sitting 3.8° southwest of the star at 20:30 BST (19:30 UT). If you can find it, also give Castor (Alpha (α) Geminorum) a go; that's 4.5° north-northwest of Pollux.

On the next evening at the same time, the now 42%-lit waxing crescent Moon is located 3° northwest of Mars, giving you an opportunity to try to spot the mag. +1.0 planet in daylight too. The advantage of making these attempts at this time is that the Sun sets soon after, which allows you to check where the objects actually were in relation to the Moon.

> ***To see a bright star in the daytime, you'll need a bit of optical assistance***

On 5 May, the centre of a 62%-lit waxing gibbous Moon is located 1.3° north and a fraction east of mag. +1.3 Regulus at 20:30 BST (19:30 UT). You could also try this one a little earlier, the Moon being 1.3° due north of the star at 19:25 BST (18:25 UT).

If you can find the 18%-lit waning crescent Moon at around 15:00 BST (14:00 UT) on 23 May, when it's around 20° above the west-southwest horizon, Venus will be 6.1° due east of the Moon's centre, making the planet very easy to find telescopically at this time. Venus is an easy object to find in a clear daylight sky and, even if the weather is poor for your attempt, hopefully you'll have had more success with one of the other suggestions. Clear daytime skies!

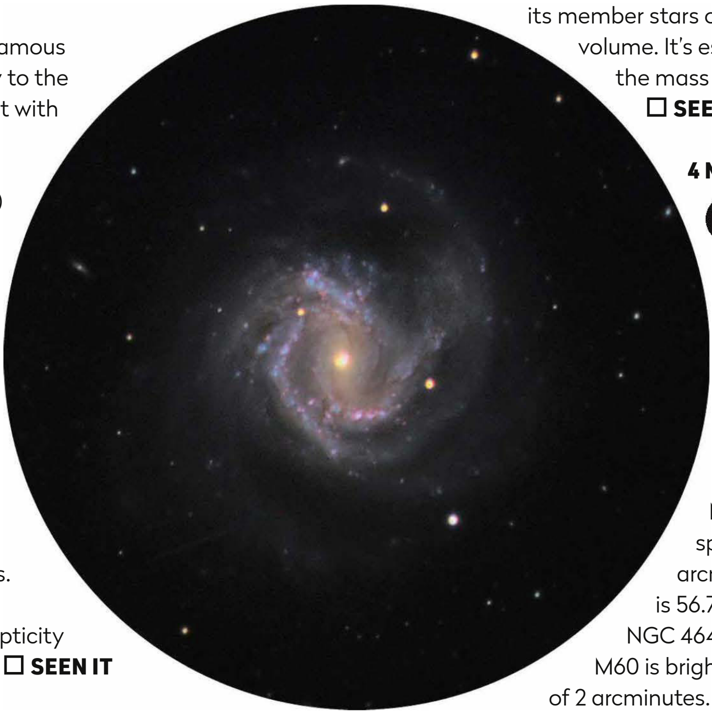

23 May, 15:00 BST (14:00 UT)
Venus sits 6.1° due
east of the Moon

DEEP-SKY TOUR

Discover some unusual elliptical galaxies as we plunge into the Bowl of Virgo

1 M86

The Bowl of Virgo is famous for indicating the way to the Realm of the Galaxies. We'll start with M86 which conveniently lies halfway along the line from Vindemiatrix (Epsilon (ε) Virginis) towards Denebola (Beta (β) Leonis). This is classed as a lenticular/elliptical galaxy of type S03/E3. At a distance of 52 million lightyears, M86 holds the record for the fastest-approaching Messier object, speeding towards us at 244km/s. This is due to it and the Milky Way heading towards the centre of the Virgo Cluster from opposing directions. Visually, the galaxy shows little structure save for its obvious ellipticity and brightness towards its core. ☐ **SEEN IT**



▲ **M61, our sixth pick, is a comparatively conventional beauty after the eclectic ellipticals on our tour**

MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM

2 M84

M84 sits 17.1 arcminutes west of M86 and acts as a good comparator. It's 55 million lightyears away and, on paper, brighter at mag. +9.2 compared to M84's mag. +9.3. But surface brightness is everything and M84's more compact form makes it appear a little brighter. M84 is a giant elliptical classified as E1 in shape, meaning it shows a 10 per cent flattening. All scopes show it as an elliptical haze, brightening significantly towards its core. A 250mm scope shows a 2.5 x 2.0-arcminute glow, smaller than M86's 3.5 x 3.0 arcminutes. M84 and M86 mark the western end of the famous curving string of galaxies known as Markarian's Chain. ☐ **SEEN IT**

3 M87

Next is the giant elliptical M87. One of the most massive galaxies known, it can be found 1.5° east-southeast of M84, a relatively bright glowing circular haze around 4 arcminutes across. Its core is well-defined, occupying an area almost 50 arcseconds across (similar to the apparent diameter of Jupiter). Also known as Virgo A, M87 lies 16.4 million lightyears away. Its physical diameter is 132,000 lightyears. Compared to the 106,000-lightyear diameter of the Milky Way, this may not seem that much larger, but M87 is elliptical (type E0-1 pec.), its member stars occupying an almost spherical volume. It's estimated to be around twice the mass of our Milky Way Galaxy. ☐ **SEEN IT**

4 M60

M60 is yet another elliptical, classified as type E1.5 or sometimes as S0, which is lenticular. It sits 3.2° east-southeast of M87 or 1.4° north-northeast of Rho (ρ) Virginis. A telescope reveals a glowing mass with no real structure except for obvious brightening towards its core. M60 is not alone; intermediate spiral galaxy NGC 4647 sits 1.7 arcminutes to the northwest. M60 is 56.7 million lightyears distant, while NGC 4647 is 63 million lightyears away. M60 is brighter, with an apparent diameter of 2 arcminutes. With a 300mm scope, NGC 4647 is 1 arcminute across, a haze without much in the way of any central condensation, while M60 is bright and beautifully concentrated. ☐ **SEEN IT**

5 M49

You'll need to head 4.9° southwest from M60 for M49. This is another giant elliptical, this time 56 million lightyears away. It's a bright object with an apparent integrated magnitude of +8.4. Appearing 4 arcminutes across through a 250mm scope, its surface brightness is fairly high allowing you to discern brightening towards a distinct core with a bright star-like nucleus at its centre. Our galaxy has around 200 globular clusters in orbit around the galactic centre. M49 has an estimated 5,900 – but even this is slightly less than half the 13,450 estimated to orbit M87! M49 is the first member of the Virgo Galaxy to be identified as such. ☐ **SEEN IT**

6 M61

Travel further into the Bowl of Virgo asterism for our last tour target. M61 is located 4° south-southwest of M49 or 1.2° and slightly to the east of mag. +5.0 16 Virginis. Unlike our previous targets, this is not elliptical but an intermediate barred spiral (type SAB(rs)bc); intermediate means it sits between being truly barred and unbarred. While up to now we've been looking at elliptical galaxies that look almost spherical through the eyepiece, M61 really is a face-on spiral, appearing as a circular glow through smaller instruments. A 250mm scope shows mottling surrounding the bright core, a 300mm instrument hinting at the presence of spiral arms. M61 is 53 million lightyears away. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
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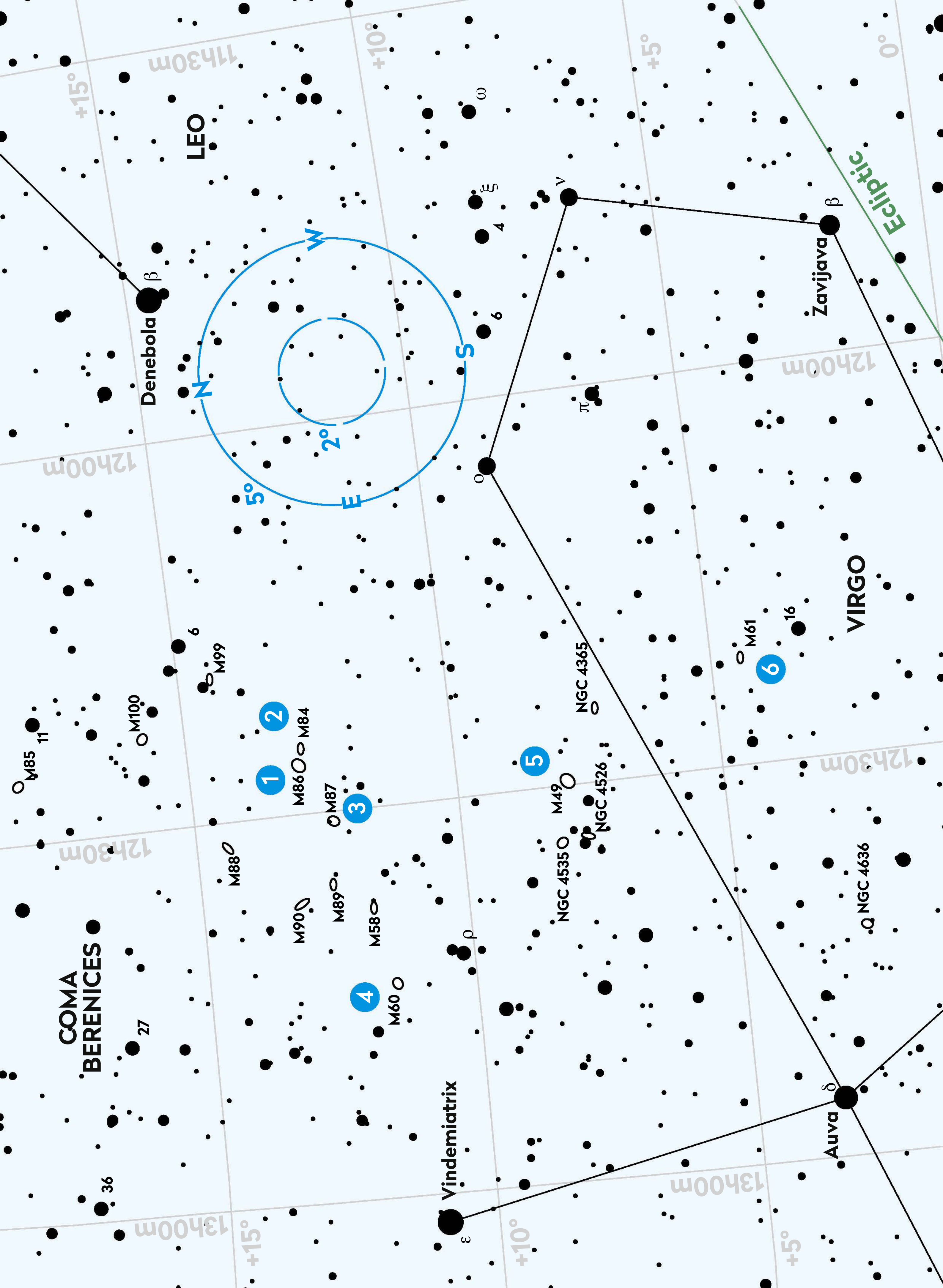
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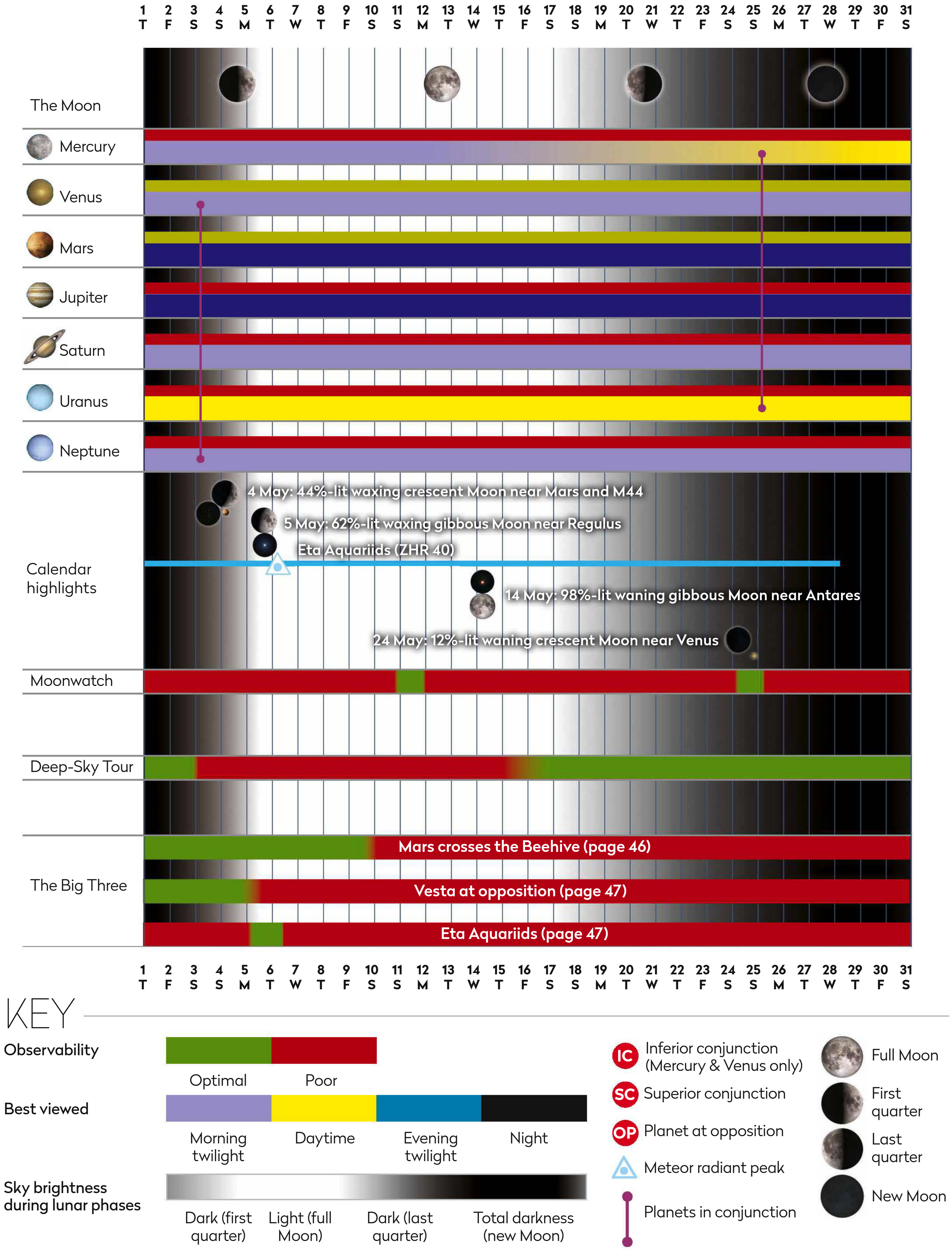
AT A GLANCE

How the Sky Guide events will appear in May



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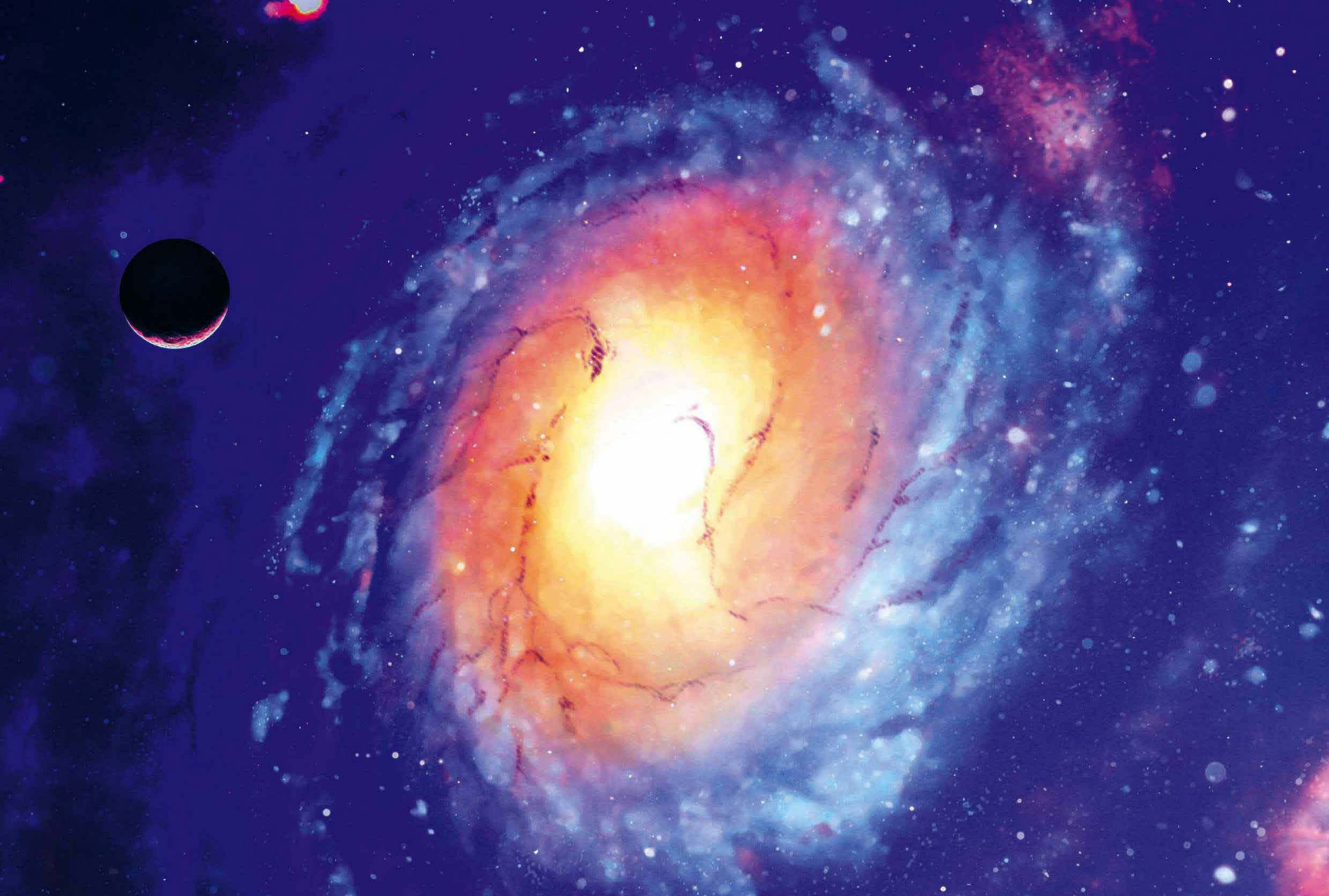


Are we ALONE?

We asked the experts

Four specialists in the hunt for extraterrestrial life tell **Ezzy Pearson** how they're hoping to find aliens

ILLUSTRATION: FIGURE: LIXU/GETTY, COSMOS: MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY

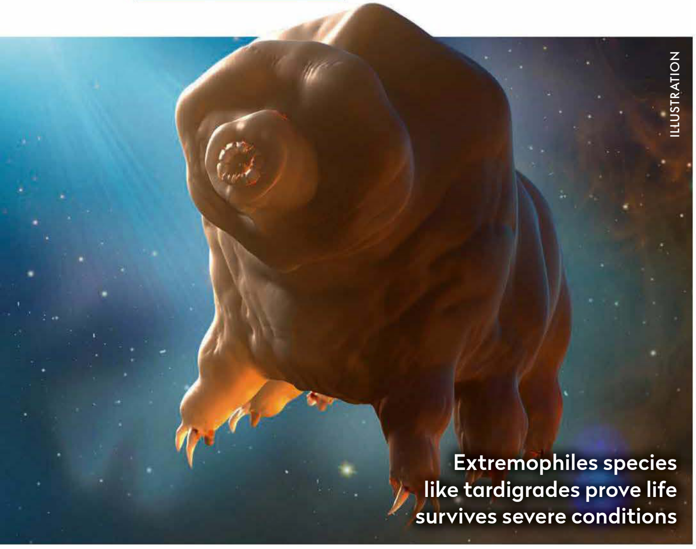
For centuries, humanity has asked itself whether it is alone in its ability to comprehend and investigate the cosmos, and whether Earth is the sole bastion of life in the Universe or simply a single outpost among billions of inhabited worlds. In the past, the exploration of extraterrestrial life was firmly left to the realm of science fiction, but in recent years the hunt for aliens has become an increasingly focused area of rigorous scientific research – from looking for echoes of Earth's habitats in our neighbouring worlds to searching for signals from distant star systems. We spoke with four of the leading figures involved in the hunt – an astrobiologist, an icy moon explorer, an exoplanet expert and a SETI searcher – to find out why we're closer than ever to finding an answer. ▶

Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is out now

It's a big Universe out there. Are we really the only life forms in it? We get answers from four people working on the cutting edge of alien-hunting science

Penny Boston

Pioneers the field of astrobiology at the Ames Research Center



Extremophiles species like tardigrades prove life survives severe conditions

What is astrobiology?
Astrobiology is anything that touches on the quest for understanding whether there are other life forms in the rest of our Universe. It really is an all-encompassing, multidisciplinary area of research, looking at the bodies in our own Solar System for signs of past or present lifeforms, all the way out to the study of exoplanets.

How are you helping in the search for alien life?
I look at extreme life forms here on Earth as a template for other environments. Those that tolerate extreme environmental conditions – high temperatures, being frozen, being trapped in a salt crystal, those that process minerals rather than eating organic carbon made by plants. Other folks have studied some small animals, like tardigrades. Everybody loves a tardigrade – they can tolerate a whole lot.

> “Mars has been in our sights for decades as a potential place to look for life”

How does learning about Earth help us find aliens?
There is no extreme environment on Earth that is an absolute match for another planet, so we extract nuggets of information about how an organism would make its living in an environment that has some similarities to an extraterrestrial one.

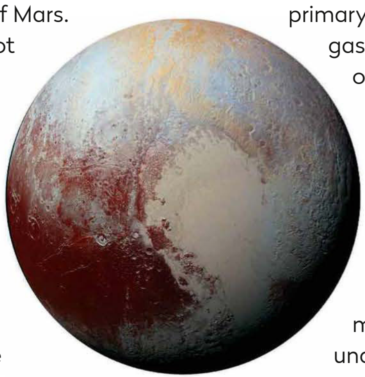
For example, we’re very interested in the deep subsurface of Mars. We know a lot about deep subsurface microbiota here on Earth, down to many kilometres. It gets very hot, but there are exotic organisms living off hydrogen. It’s a template for stimulating our thinking about how microorganisms may have arisen and adapted on another planet.

Do we currently have the technology to find life?
The answer is probably yes and no. Opinion about this varies widely throughout the scientific community.

We have a good grasp of detecting biopolymers: big molecules that store information like DNA… if we can get to the environment. There’s a lot of attention right now on trying to advance pinpoint landing and engineering robotics that can get us into rougher terrain.

Where is the best place to look for life beyond Earth?
Anywhere with the potential for liquid water. We take water for granted, but it’s quite extraordinary. Within the temperature range of our planet, it has the ability to exist in all three major primary phases: solid, liquid and gas. It enables the chemistry of life to actually occur.

Mars has long been in our sights for many decades as a potential place to look for life. Several of the icy moons around Jupiter and Saturn have liquid material in their interior under kilometres of ice. One of my favourites is Pluto; it turned out to be a geologically incredibly active body. We really do have quite a list that we want to investigate in the coming decades.



▲ Icy on the surface but warm inside, Pluto may have a subsurface ocean

***Penny Boston** is an astrobiologist and researcher at NASA’s Ames Research Center*

Astronaut ‘cavewalk’ training for subterranean alien environments

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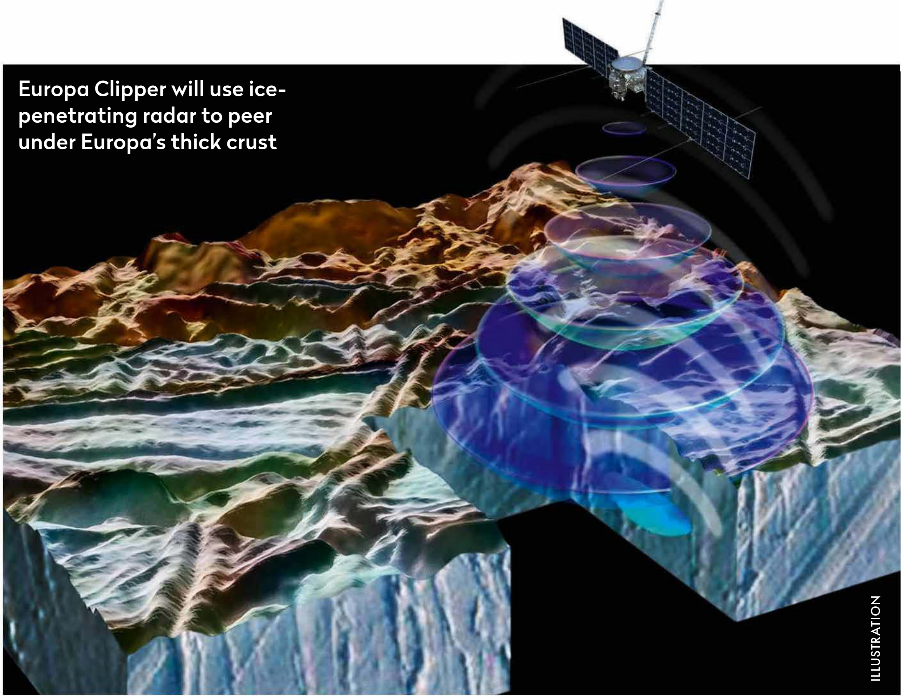
Bonnie Buratti

Explores icy moon habitability at NASA's Jet Propulsion Lab



Europa Clipper will use ice-penetrating radar to peer under Europa's thick crust

ILLUSTRATION

How are you helping in the search for alien life?
I serve as the deputy project scientist of Europa Clipper, a NASA flagship mission to explore one of Jupiter's moons, Europa. We're almost certain it has a subsurface ocean and we're trying to determine whether life could be sustained in that ocean. We're not a life-detection mission; that's a little too sophisticated. We're just looking for a habitable environment.

What will you be looking for?
There are three necessities for life as we know it: liquid water, energy and food. The building blocks of life as we know it are carbon, hydrogen, oxygen and nitrogen. We're going to be looking for minerals that have those types of chemicals in them and mapping them on the surface.

Why are you looking on Europa?
We're fairly certain that Europa has a subsurface ocean, and ground-based observations have also found evaporate deposits on its surface – things like magnesium salts and carbon dioxide. It's very complex chemically.

The current idea is that life developed on Earth in the deep oceans where thermal vents, so-called smokers or oceanic vents, seem to have developed primitive bacteria. We think there might be a similar environment on Europa.

Ocean worlds may be fairly common in our Solar System. This is the first one we're exploring in detail. Now that we've discovered so many planets around other stars, it opens up a whole new area to look for habitable environments.

What might a mission to search for life on Europa look like?
We know so little about this. We don't even really understand how life arose on Earth. On Europa, you have to get through a crust that's about 15 to 20 kilometres thick. We're not sure how deep it is; that's one of the things we have to find out. We have an ice-penetrating radar to see if there are any ponds under the surface.

To understand the problem, look at Antarctica where there are subglacial oceans like Lake Vostok. We barely have the technology to get down there here on Earth, when we don't have to deal with the strong magnetic field of Jupiter and trying to get miniature instruments on spacecraft. Right now, we really don't have the technology to look into subsurface oceans in the outer Solar System.

Europa's strange streaked surface could hide massive underground oceans

> "Right now, we really don't have the technology to look into sub-surface oceans"

Do you think there is life out there in the Solar System?
You only have scientific opinions based on the evidence and right now, we don't have any evidence. We're just looking for an environment in which life could thrive or even exist.

Bonnie Buratti *is a JPL fellow and a senior research scientist and deputy project scientist of Europa Clipper* ▶

Lisa Kaltenegger

Investigates exoplanet atmospheres at the Carl Sagan Institute

How are you helping in the search for alien life?

I'm trying to figure out, remotely through a telescope, how we can find life on planets orbiting other stars. I look at the starlight filtering through the air of planets to tell me what's in the atmosphere of these other worlds. Earth's life has significantly changed our atmosphere, so I'm looking for where life has altered either the atmosphere or the surface of the planet so much that I can tell the difference.

What is it that you're looking for in exoplanet atmospheres?

The combination of chemicals that we cannot explain without invoking life. The best combination that we have right now is oxygen with a gas like methane. Those two gases react with each other, so if they're in the air right now it tells you that both are being produced in huge amounts. For that combination, we have no other explanation than there being life. What that doesn't do is tell us what kind of life – it could mean slime mould or dinosaurs, or us.

Do we currently have the technology we need to find life?

What I find so fascinating is that we went from "it's impossible" to "it's possible". That's the James Webb Space Telescope. But we're not anywhere close to "it's easy"! The more light we can get, the more time we get to look at these planets and the more we can tell you. There is hope that we will get a space telescope just for the search for life.

We know one in five stars have planets about the size of Earth in their habitable zone

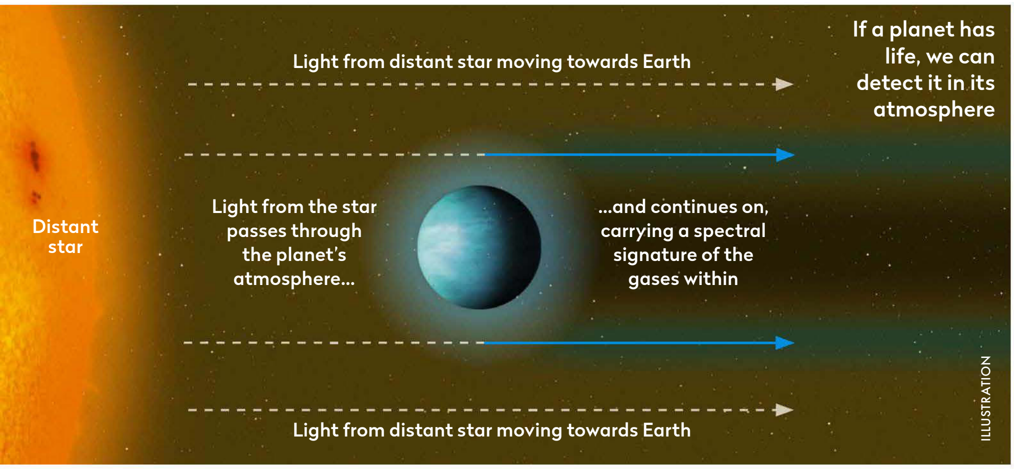
ILLUSTRATION

Do you think there is alien life out there waiting to be found?

What we know right now is that one out of five stars has a planet in the habitable zone that's small enough to be rocky. We have 200 billion stars in our Galaxy alone, and there are billions of galaxies. The biggest surprise would be if we find nothing. However, the key point is 'find', because it's so hard to actually find it.

I think that's a numbers game. Right now, we know of 48 worlds that could be like ours. If we're really lucky and a planet close to us shows signs of life that we can spot, then we can do it with JWST.

> "The biggest surprise would be if we find nothing. However, the key point is 'find'"



Light from distant star moving towards Earth
If a planet has life, we can detect it in its atmosphere
Distant star
Light from the star passes through the planet's atmosphere...
...and continues on, carrying a spectral signature of the gases within
Light from distant star moving towards Earth
ILLUSTRATION

What impact would it have if we found alien life?

People of my generation think it will have this huge effect. But 1995 was when the announcement was made of the first planet around another star; my students have never lived in a world where they didn't know whether there were planets around other stars. It's not going to be shocking if we find something. For them the question is, when are you going to figure out if there's life out there?

However, if there were a UFO landing on the White House lawn saying, "Take me to your leader", I don't know what effect that would have!

***Lisa Kaltenegger** is the director of the Carl Sagan Institute at Cornell University and a professor of astrophysics*

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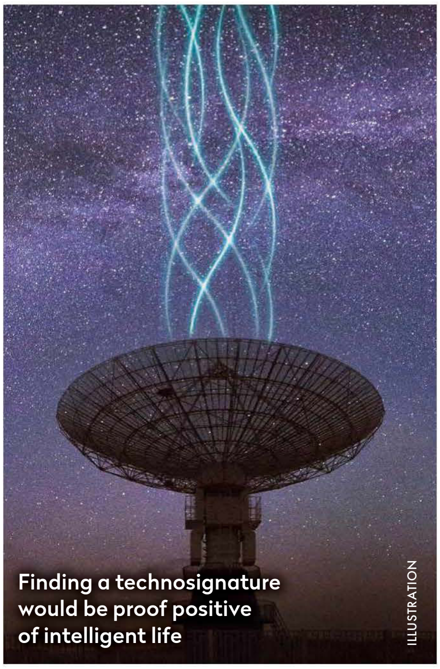
Frank Marchis

Hunts for signals from alien civilisations at the SETI Institute


Finding a technosignature would be proof positive of intelligent life

ILLUSTRATION

How are you helping in the search for alien life?
I work for the SETI Institute. SETI is the search for extraterrestrial intelligence. One thing we look for is technosignatures – signals that can't be explained by natural phenomena because they're too complex. They could be the light from cities on a planet, telecommunication signals or even the presence of artificial chlorofluorocarbon molecules (CFCs) in an exoplanet atmosphere.

What advantages does SETI have over other ways of searching for life?
A technological signature is an obvious signature. If one day we find the signature of life in the atmosphere of an exoplanet, there will be a huge debate about whether or not this is life. If we detect a radio signal which is not natural, we'll know something made it right away.

But SETI is a very binary thing. In other searches, there is an incremental discovery that happens. For the SETI researcher, it's yes or no. It's yes, you discovered something, or no, you did not. Agencies hate that; they want to see results being made steadily.

What is the public involvement with SETI?
One of my roles at the Institute is to develop citizen science for SETI. I am also the CSO of a telescope company called Unistellar which makes small telescopes, and I develop citizen science around those telescopes and their users. We have 3,000 registered users of these telescopes all around the world, so we can observe the sky all the time. We are training this team of people to learn how to do research using the telescopes, to study comet activity, asteroids that fly by Earth, satellites and other things. So if one day SETI detects a signal, we can ask this network to continuously monitor it.

Do we currently have the level of technology needed to detect these signals?
Frank Drake used to say SETI is a way to anticipate the future. For example, we expect advanced civilisations to have built gigantic 10-gigawatt lasers to communicate with other planets. We're building instruments to detect those, assuming one day – maybe 100 years from now – humans will build these powerful lasers to propagate through space. But those aliens, maybe they already did it. It's science fiction meets science; what is the next big step in humanity's evolution and technology?

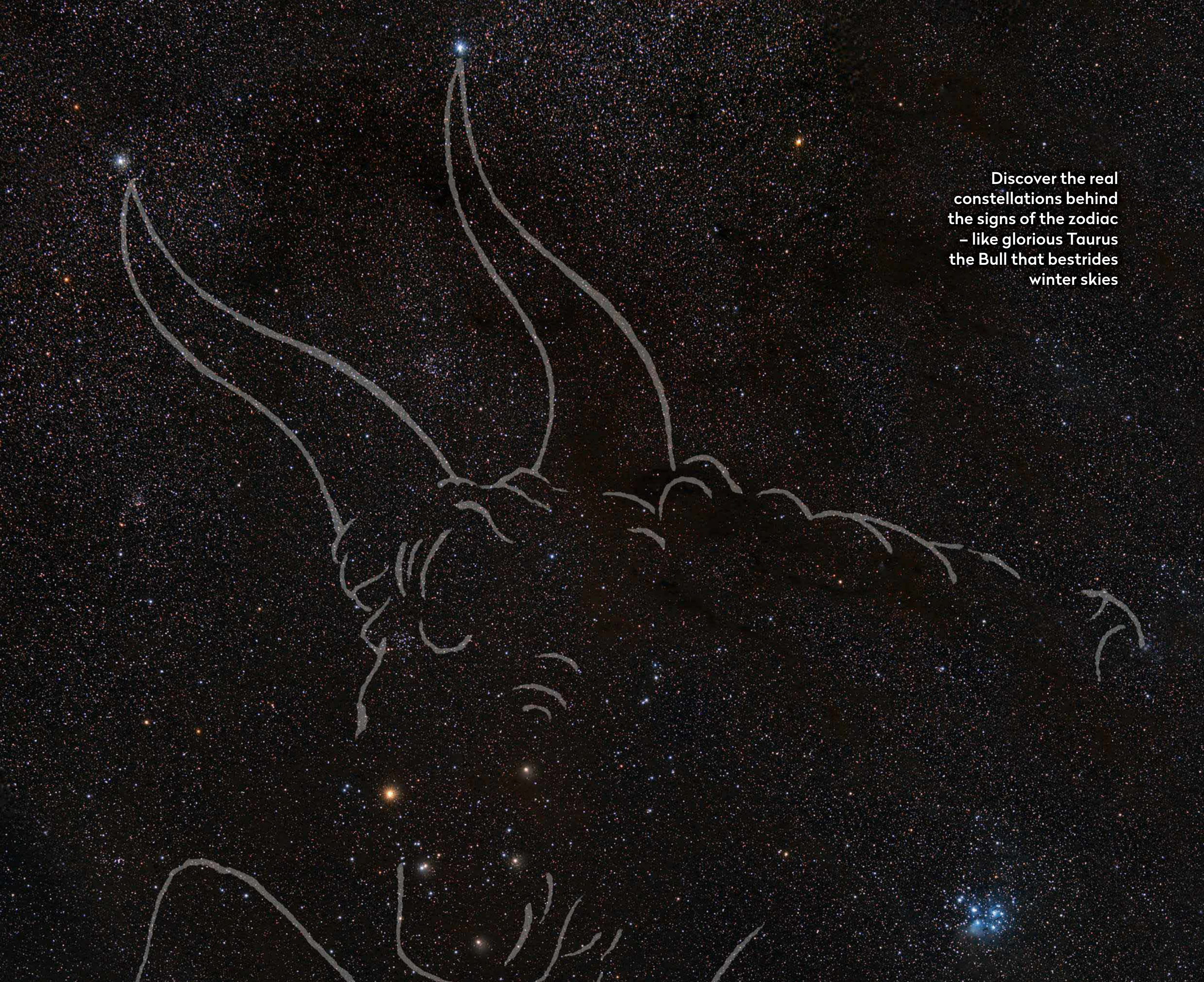
> *"Finding an alien will tell us 'You're not an anomaly'. We'll know we have a future"*

What would be the impact of finding life beyond Earth?
For me, it will have a huge impact because that's something I really want to witness in my life. Right now, we are the only biological, technological, intelligent civilisation. Is that something that evolution makes happen, or is that an anomaly? Maybe our civilisation is not something that can last for long. Finding an alien like us will tell us "You're not an anomaly". We will know we have a future as a civilisation.

***Franck Marchis** is director of citizen science at the SETI Institute and CSO of Unistellar*

ILLUSTRATION

Global networks of telescopes are on alert to detect laser signals from space



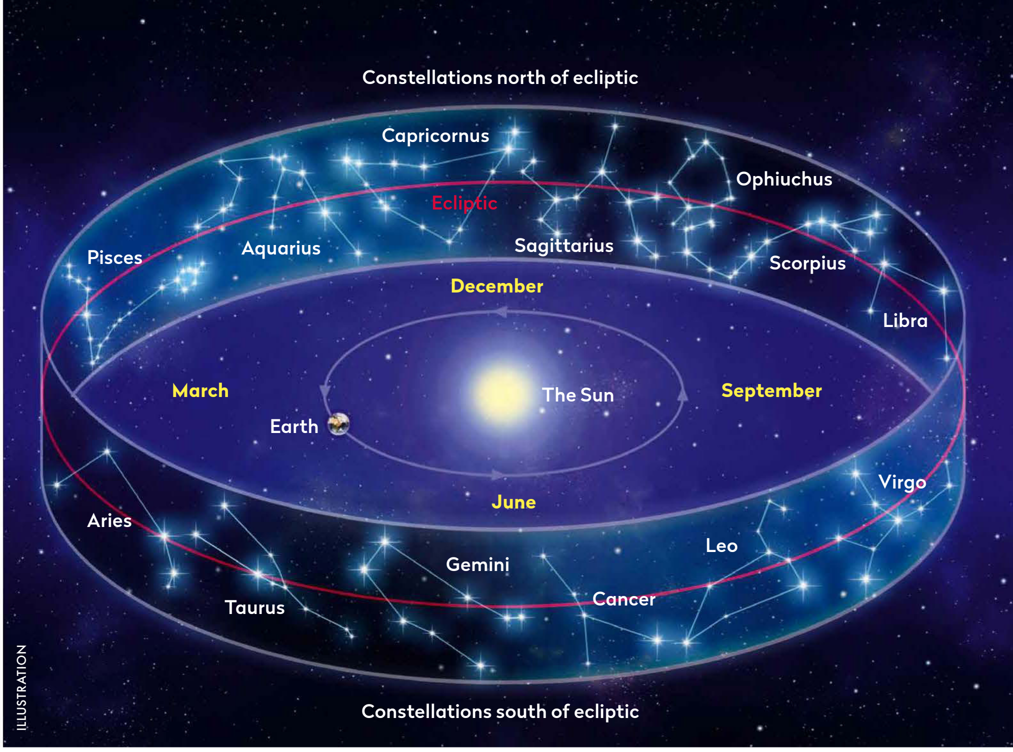
Discover the real constellations behind the signs of the zodiac – like glorious Taurus the Bull that bestrides winter skies

The stars behind the star signs

An astronomer's journey through the real zodiac

Mary McIntyre takes us on a guided tour of the 13 zodiacal constellations and their most beautiful night-sky jewels

Mary McIntyre is an astronomy educator, author and co-host of *BBC Sky at Night Magazine*'s Star Diary podcast



ILLUSTRATION

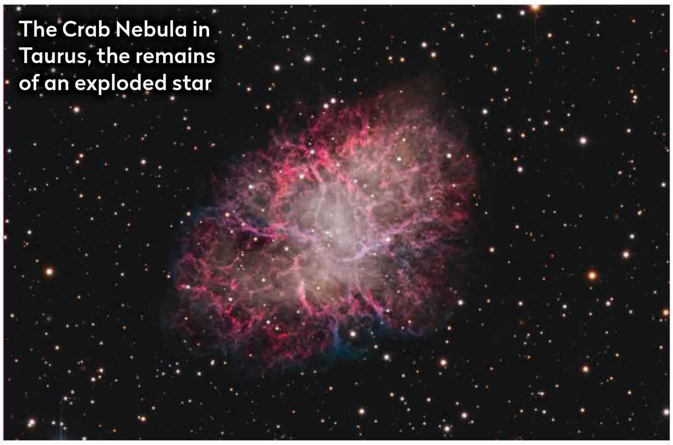
▲ From our perspective on Earth, the Sun traces a great circle against the background of the stars (the ecliptic), passing through the 13 zodiac constellations throughout the year

We've all heard of the zodiac and 'star signs', whether we believe in the latter or not. But you may be unaware that the signs of the zodiac are real constellations in the night sky, just waiting to be observed and explored.

The origins of the zodiac lie in early civilisations that relied on the movement of the Sun, Moon, planets and stars to mark the passage of time. Our ancestors realised the Sun and planets passed through a small group of constellations along an imaginary line known as the 'ecliptic', which is the plane of the planets' orbit around the Sun, as seen from Earth. The ancient Greeks called this the zodiac, meaning 'circle of little animals' because most of these constellations were named after animals. In astrology, the zodiac is divided into 12 'signs', but in astronomy we know the Sun actually moves through 13 constellations over the year (the 'extra' one being Ophiuchus) and most are visible for several months. They climb the dawn twilight in the east and are visible earlier each night as they move westwards until, months later, they sink into evening twilight in the west. As a result, the path the Sun takes during a year appears to be moving backwards against the zodiac (see chart overleaf). Due to precession – the slow change in the direction of Earth's rotational axis – the Sun no longer travels through them on the same dates as it did when the signs were first assigned.

Let's take an astronomer's tour of the real zodiac – the 13 constellations and the best night-sky targets to see in them.

NGC 772 in Aries, discovered by William Herschel in 1785



The Crab Nebula in Taurus, the remains of an exploded star

Aries

Best time to see: September to February
Sun transits this sign: 19 April–14 May

In mythology, Aries has represented a ram since late Babylonian times. It's a relatively faint constellation with just four bright stars. The brightest, **Hamal**, is an evolved giant star that shines at magnitude +2 (mag. +2). The mag. +3.6 star **Bharani** lies at the bottom of a triangle-shaped star pattern that formed the old constellation Musca Borealis, the Northern Fly. Aries contains the spiral galaxy **NGC 772**, which is observable with amateur telescopes, plus lots of fainter galaxies. It houses the meteor shower radiants – the region in the sky that meteors appear to come from – for two daytime showers, the **Arietids** and **Delta Arietids**.

Taurus

Best time to see: September to March
Sun transits this sign: 14 May–21 June

Depictions of Taurus as a bull date back to around 15,000 BC, and the bull is present in many cultures' ancient mythology. The brightest star is the red giant **Aldebaran**, which has a magnitude range of +0.75 to +0.95. The distinctive V-shaped **Hyades** cluster and stunning open cluster Messier 45, the **Pleiades**, are visible with the naked eye but binoculars reveal many more stars. Taurus has plenty of smaller clusters, including **NGC 1674** and **NGC 1746**. Messier 1, the **Crab Nebula**, is the remnant of a supernova explosion recorded in the year 1054. Taurus is also home to the **Northern Taurids** and **Southern Taurids** meteor shower radiants. ▶

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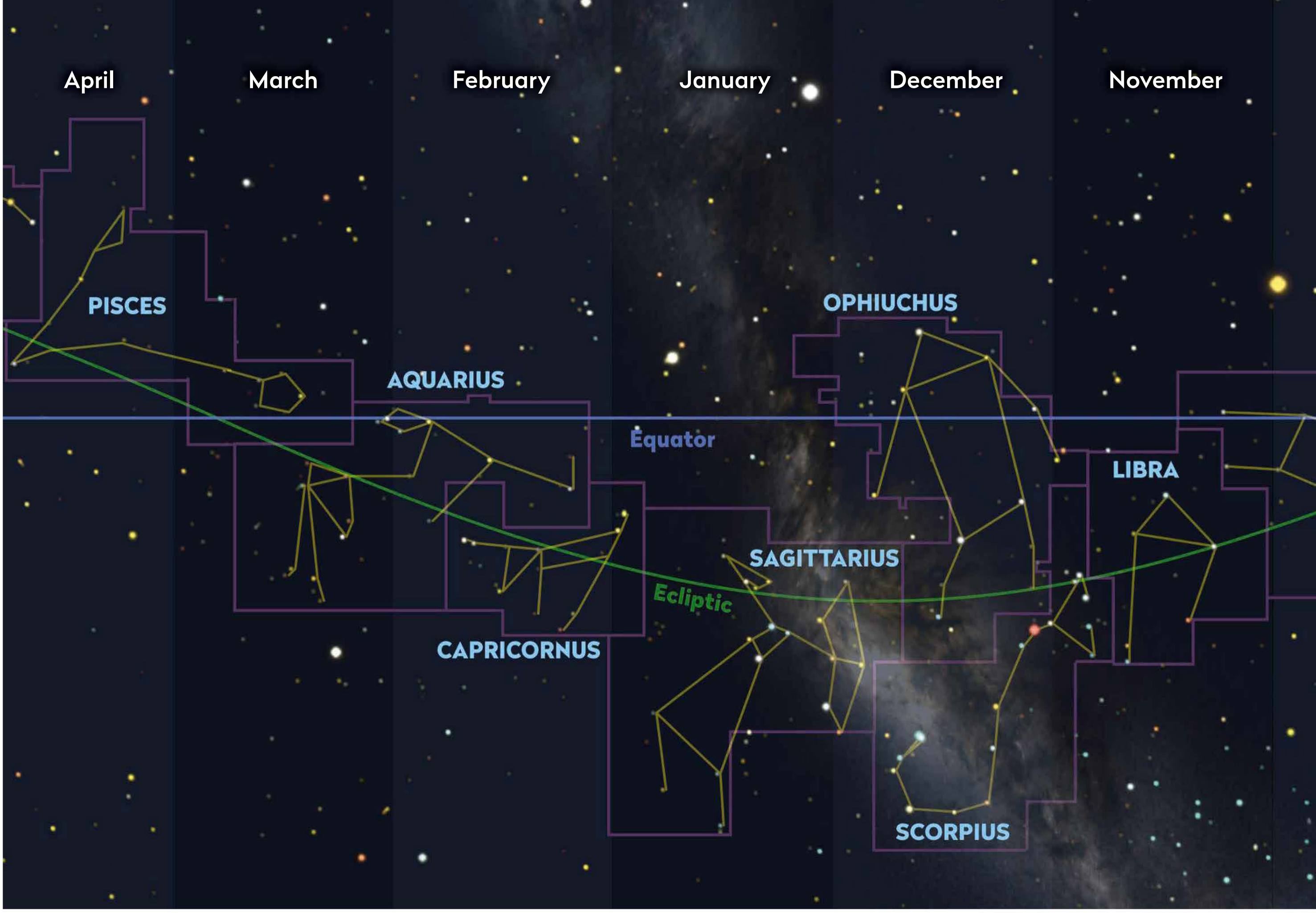
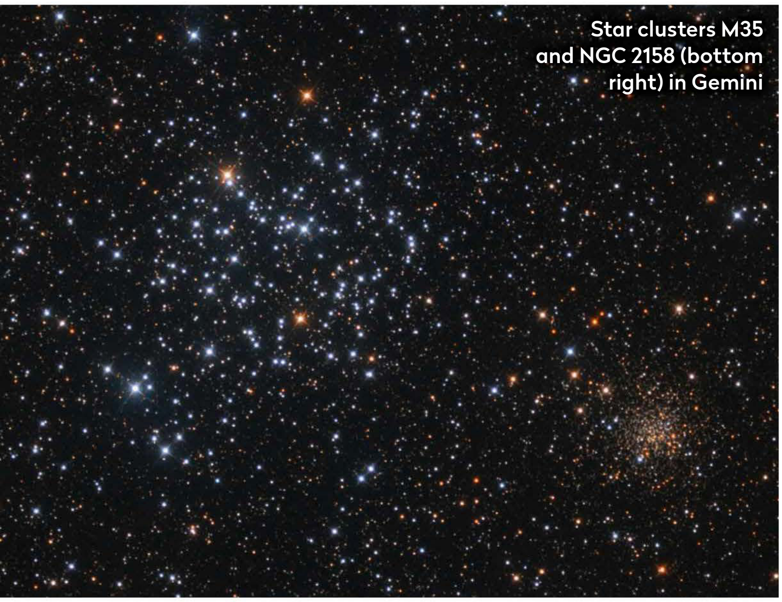


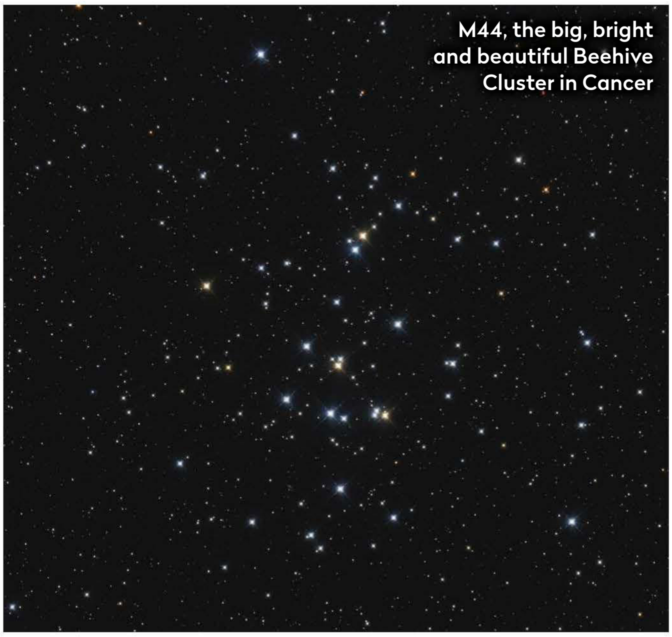
Gemini

Best time to see: October to March
Sun transits this sign: 21 June–20 July

Mythology associating Gemini with twins dates back to Babylonian times. It's a prominent constellation with 85 naked-eye visible stars. The brightest are the twins **Castor** and **Pollux**, which are mag. +1.6 and +1.14, respectively. Although similar in magnitude, Castor is blue-white while Pollux is a red giant. Gemini contains many open star clusters, the brightest being **Messier 35**, a cluster of 200 stars. A smaller cluster, **NGC 2158**, lies south of it. The radiant for one of the year's best meteor showers, the **Geminids**, lies in Gemini, with the **Orionids** radiant also passing through.



Star clusters M35 and NGC 2158 (bottom right) in Gemini



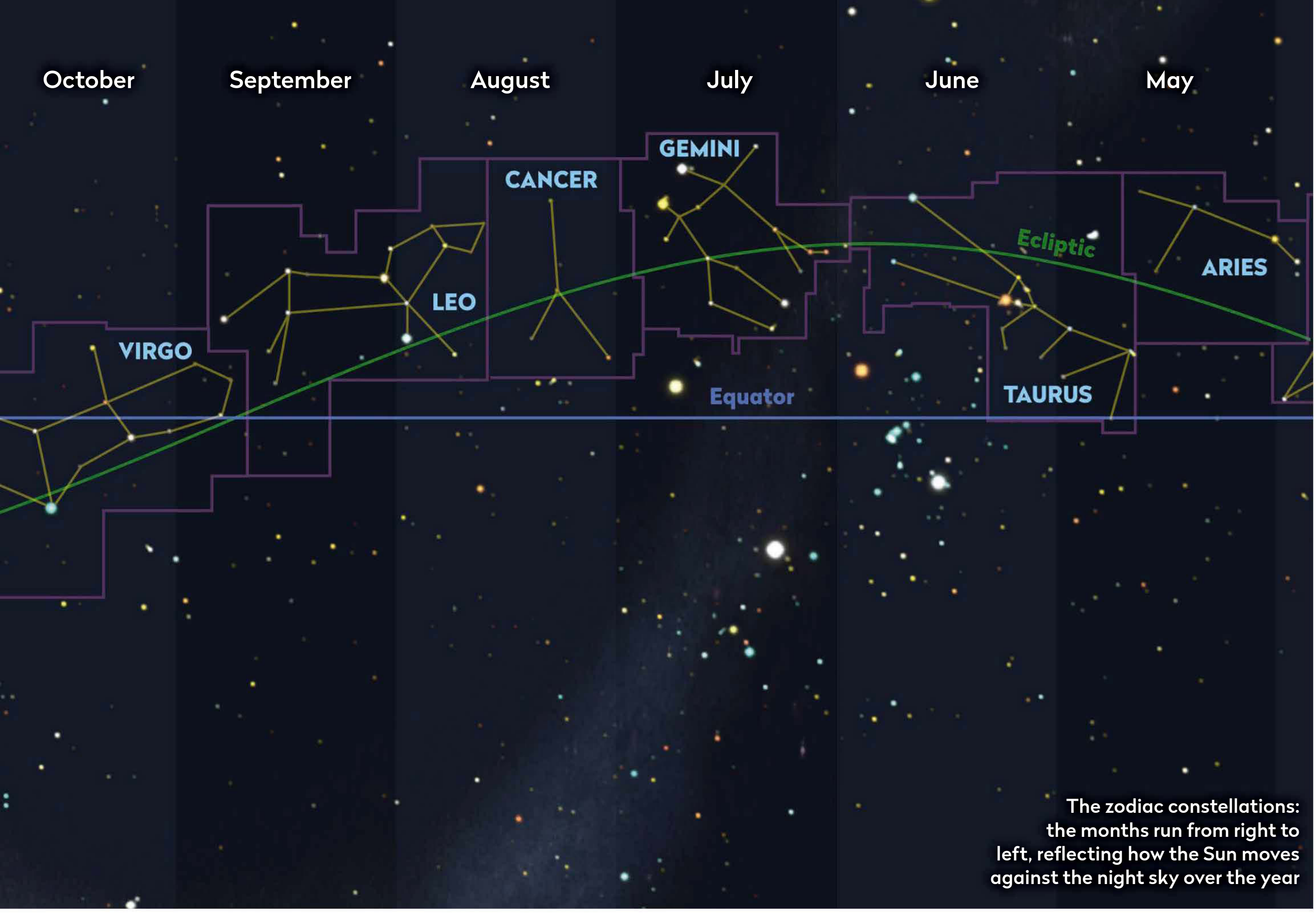
M44, the big, bright and beautiful Beehive Cluster in Cancer

Cancer

Best time to see: November to April
Sun transits this sign: 20 July–10 August

In Greek mythology, Cancer represents the crab killed by Hercules. It is a dim constellation with only two stars above mag. +4. The brightest is the orange giant **Tarf**, a mag. +3.5 binary star. **X Cancri** is a variable carbon star with a magnitude range that fluctuates between mag. +5.52 and +7.50 over 193 days. The highlight of this constellation is Messier 44, the **Beehive Cluster**, also known as Praesepe – meaning 'manger'. It contains around 1,000 stars spread across 1.5°, making it a stunning binocular object.

STELLARIUM X 4, CHART BY PETE LAWRENCE, MARKUS BLAUENSTEINER/CCDGUIDE.COM, FRANZ KLAUSER/MANFRED WASSHUBER/CCDGUIDE.COM, CHRISTOPH KALTSEIS/CCDGUIDE.COM, JOHANNES SCHEDLER/CCDGUIDE.COM



The zodiac constellations: the months run from right to left, reflecting how the Sun moves against the night sky over the year

Leo

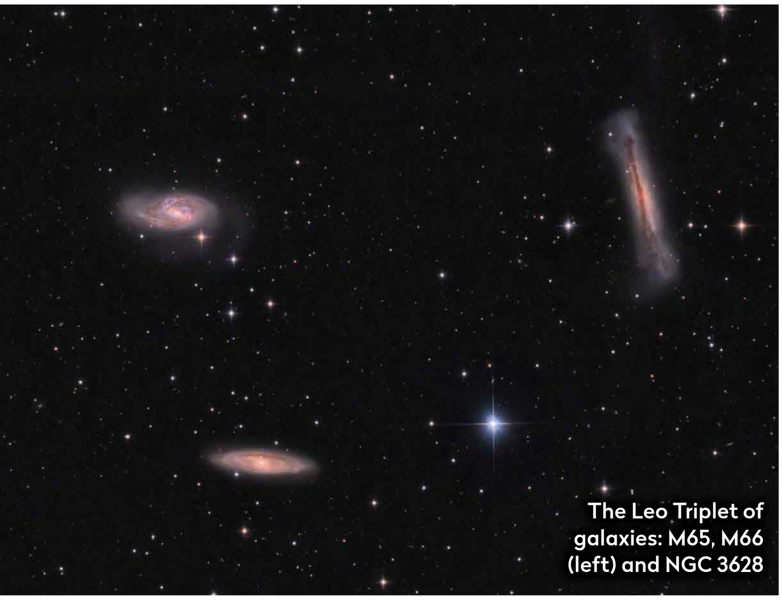
Best time to see: December to April
Sun transits this sign: 10 August –16 September

Leo is one of the oldest recorded constellations. In Greek mythology, it represents the lion killed by Hercules, with the **Sickle star pattern** often depicted as the lion's mane. It's a prominent constellation and its brightest star, **Regulus**, is a mag. +1.34 blue-white double star; binoculars will resolve its mag. +7.7 companion. Leo is packed with galaxies bright enough to be viewed with binoculars, the best known being the **Leo Triplet** comprised of M65, M66 and NGC 3628. The radiant of the **Leonid meteor shower** lies in Leo.

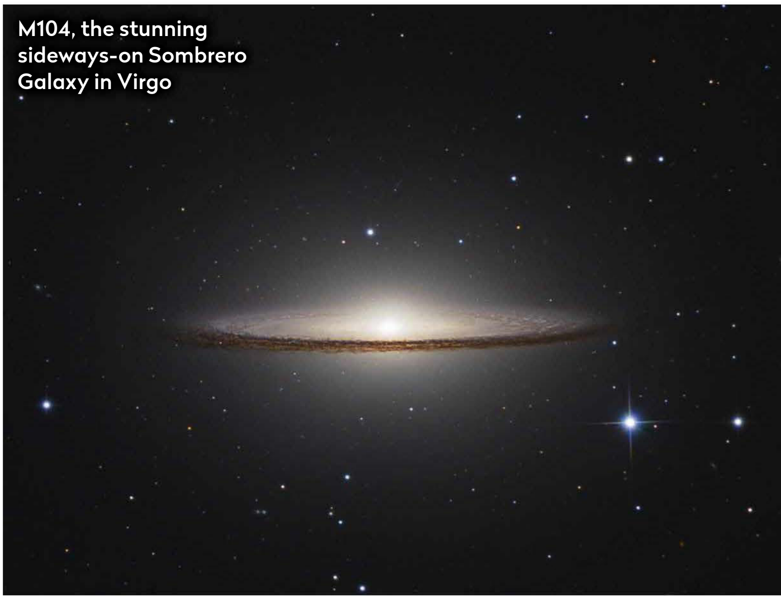
Virgo

Best time to see: February to May
Sun transits this sign: 16 September –31 October

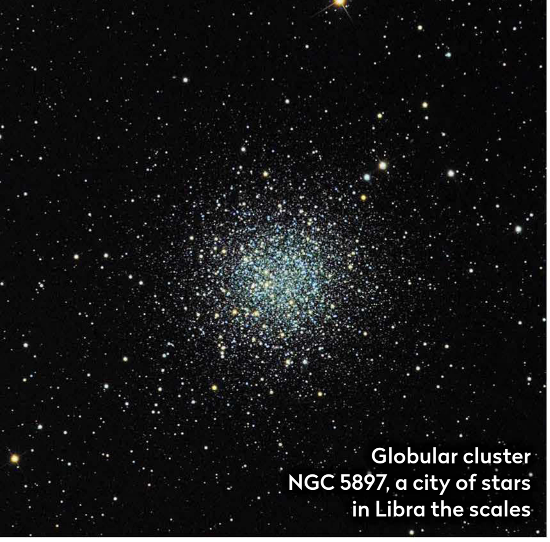
Mythology links Virgo – the largest of the zodiac constellations – with the goddess of wheat or a virgin holding the scales of justice (now the constellation Libra). Its brightest star is **Spica**, a mag. +0.97 blue giant. Virgo is home to the **Virgo Supercluster**, so it's packed with galaxies! **Messier 87** is a giant elliptical galaxy that dominates the Virgo–Coma galaxy cluster. A string of galaxies known as **Markarian's Chain** lies on the northern border – a wonderful binocular target. Messier 104, the **Sombrero Galaxy**, is also well worth a look. ▶



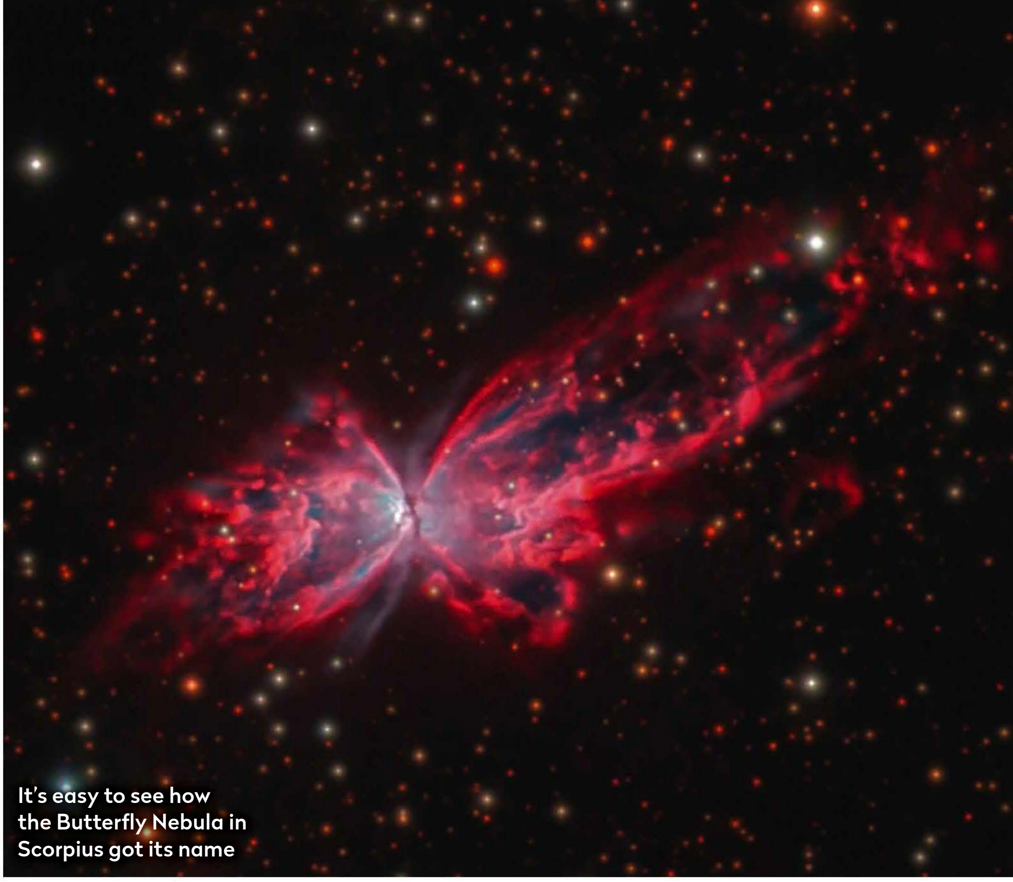
The Leo Triplet of galaxies: M65, M66 (left) and NGC 3628



M104, the stunning sideways-on Sombrero Galaxy in Virgo



Globular cluster NGC 5897, a city of stars in Libra the scales



It's easy to see how the Butterfly Nebula in Scorpius got its name

Libra

Best time to see: May to July

Sun transits this sign: 31 October –23 November

Libra, the scales, is the only zodiac constellation that represents an inanimate object. Its brightest star is **Zubenelgenubi**, a mag. +2.7 multiple-star system, two stars of which can be resolved with binoculars. **Zubeneschamali** is the second-brightest at mag. +2.6. These names translate as Southern and Northern Claw, as they refer to the claws of the original Scorpius before astrologers divided them! **17 and 18 Librae** are a beautiful colour-contrasting pair and the mag. +8.5 globular cluster **NGC 5897** is a great binocular target.

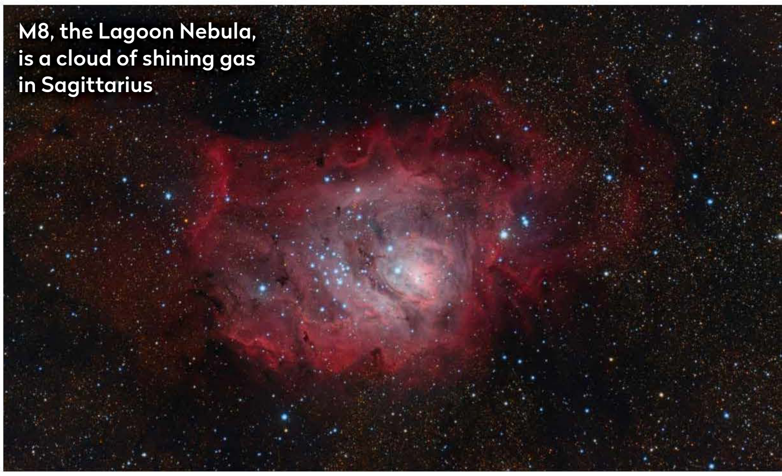
Scorpius

Best time to see: June and July

Sun transits this sign: 23–30 November

In Greek mythology, Scorpius represents the scorpion that killed Orion. Only the 'claw' can be seen from mid-latitudes. Its brightest star is orange **Antares**, a red supergiant whose name means 'rival of Mars'. Scorpius is packed with deep-sky objects. Binoculars will reveal open clusters **Messier 6** and **Messier 7**, and globular clusters **Messier 4 and 8**. It also contains NGC 6302, the **Butterfly Nebula**, a stunning nebula whose shape is a result of a dying star shedding its outer layers.

The Summer Beehive Cluster in Ophiuchus is delightful in binoculars



M8, the Lagoon Nebula, is a cloud of shining gas in Sagittarius

Ophiuchus

Best time to see: May to July

Sun transits this sign: 30 November –18 December

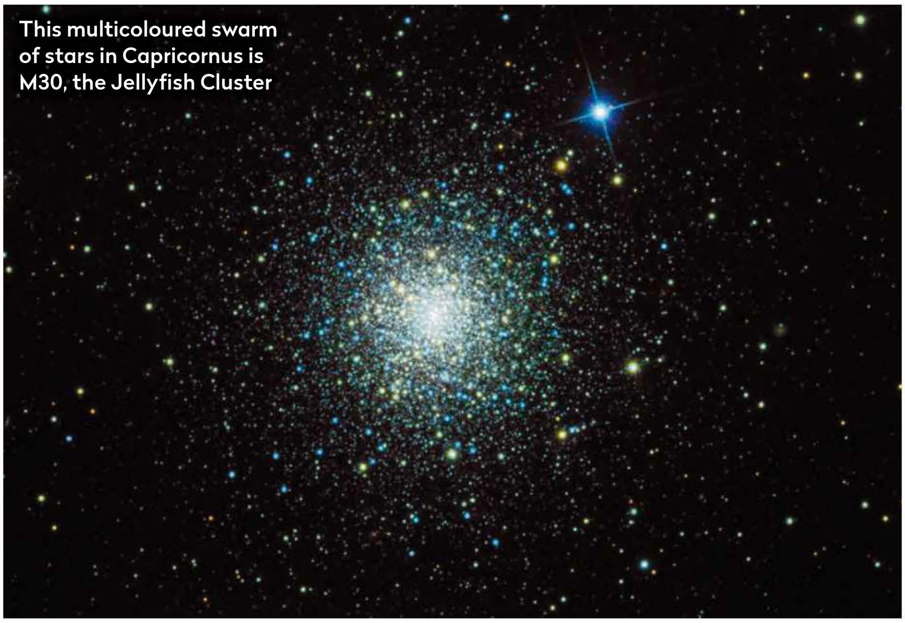
Ophiuchus, the 'unofficial' 13th member of the zodiac, is a figure often depicted holding a serpent. Its brightest star is the mag. +2 binary **Rasalhague**. Ophiuchus is home to the **Poniatowski's Bull** star pattern, resembling a miniature Hyades star cluster (the real Hyades being visible in Taurus). IC 4665, the **Summer Beehive Cluster**, is a treat in binoculars, along with nine globular clusters, including **Messier 9, 10, 12, 14, 19** and **62**. The southeastern corner contains the **Dark Horse Nebula**.

Sagittarius

Best time to see: June and July

Sun transits this sign: 18 December –20 January

In Greek myths, Sagittarius is depicted as a centaur drawing a bow. Its brightest stars form the **Teapot star pattern**, with the Milky Way rising like steam from its spout. Brightest of all is **Kaus Australis**, a mag. +1.85 binary star system. The large and small **Sagittarius star clouds** are visible from a dark-sky site. Binoculars reveal many globular clusters, including the stunning **Messier 22 and 28**. Photography targets include the **Lagoon, Omega and Triffid nebulae**.



This multicoloured swarm of stars in Capricornus is M30, the Jellyfish Cluster

Capricornus

Best time to see: June to October
Sun transits this sign: 20 January–16 February

Capricornus has had mythological associations since the Middle Bronze Age and it represents a goat–fish hybrid. It's faint, with only one star brighter than mag. +3: **Deneb Algedi** is a variable star whose magnitude ranges from +2.81 to +3.05 over a 24.5-hour period. **Beta Capricorni** is a double star, a yellow mag. +3.1 primary star contrasting with a blue-white mag. +6 star. Deep-sky objects are sparse, but Messier 30, the **Jellyfish Cluster**, is a stunning mag. +7.5 globular cluster that resembles jellyfish tentacles.

Aquarius

Best time to see: July to November
Sun transits this sign: 16 February–12 March

Aquarius is depicted in ancient Greek mythology as a figure carrying water. It's a faint constellation, its brightest star being magnitude +2.94 yellow supergiant **Sadalmelik**. It's home to two globular clusters: **Messier 2** is mag. +6.5 and **Messier 72** is fainter at mag. +9.3. It also has two nice planetary nebulae: mag. +8 NGC 7009, the **Saturn Nebula**, so named because its faint structure resembles the planet Saturn with its rings; and NGC 7293, the **Helix Nebula**, the closest planetary nebula to Earth and visually the largest. The Aquarius constellation is also home to the radiant points of three meteor showers: the **Northern Aquariids**, **Southern Delta Aquariids** and the **Alpha Capricornids**.

The incredible Helix Nebula in Aquarius is 650 lightyears from Earth

A classic beauty, the face-on spiral galaxy M74 in Pisces

Pisces

Best time to see: August to December
Sun transits this sign: 12 March–19 April

The ancient Greek myths depicted Pisces as a pair of fish. It is a large but faint constellation with only two stars brighter than mag. +4. Its brightest is **Alpherg**, a mag. +3.6 binary star system. The **Circlet** star pattern lies over the head of one fish. Colour-contrasting stars can be seen in the **Pisces Parallelogram** star pattern and the double-star system **Mu Piscium**. Turning to Pisces' galaxies, **Messier 74** is a face-on spiral galaxy, but its low surface brightness makes it a challenging target to see well. Pisces is home to many faint galaxies within galaxy clusters that make for great targets for astrophotography.

STELLARIUM X 7, DANIEL VERSCHATSE/CCDGUIDE.COM, CEDIC TEAM/BERNHARD HUBL/CCDGUIDE.COM, GÜNTER KERSCHHUBER/CCDGUIDE.COM, MARKUS BLAUENSTEINER/CEDIC TEAM/CCDGUIDE.COM, DANIEL VERSCHATSE/ CCDGUIDE.COM, CEDIC TEAM/CHRISTOPH KALTSEIS/CCDGUIDE.COM, TOMMY NAWRATIL/CCDGUIDE.COM

Stephen Hawking

Hawking's work revolutionised our ideas about how the Universe began

▲ **Advancing the ideas of Einstein, Stephen Hawking (1942–2018) brought about a seismic shift in our thinking on black holes and the Big Bang**

He was the most recognisable scientist since Albert Einstein, but what made Stephen Hawking such an enduring figure and what did he discover about our Universe?

Stephen William Hawking was born on 8 January 1942 in Oxford. Yet it was that other bastion of English academia – Cambridge – where he would make his name. In 1979, he became the Lucasian Professor of Mathematics, a hallowed post once held by Isaac Newton. Much earlier, in 1966, Hawking completed his PhD thesis at Cambridge titled 'Properties of Expanding Universes'. Newton may have described gravity as an invisible, attractive force between two massive objects, but that idea had been thrown out thanks to Albert Einstein. According to Einstein's general theory of relativity, massive objects warp the fabric of the Universe around them and other objects can get caught in this distortion. The apparent attractive force is merely an illusion caused by this.

Hawking's PhD thesis took these ideas and applied them to the very beginning of the Universe. The fabric of the Universe that's warped by massive objects is known as spacetime. Hawking's thesis contained a bombshell statement, one that lit a fire under his fledging career and set him on a path towards international stardom.

Spacetime, he said, could begin and end at a singularity. What's more, he could prove it.

A singularity is an infinitely small speck. A point with no size. To prove that such a thing could exist, Hawking envisaged a Universe with no singularities. He showed that this led to a fundamental contradiction: two opposing ideas about the shape of our Universe would simultaneously be true. As this was impossible, singularities had to exist.

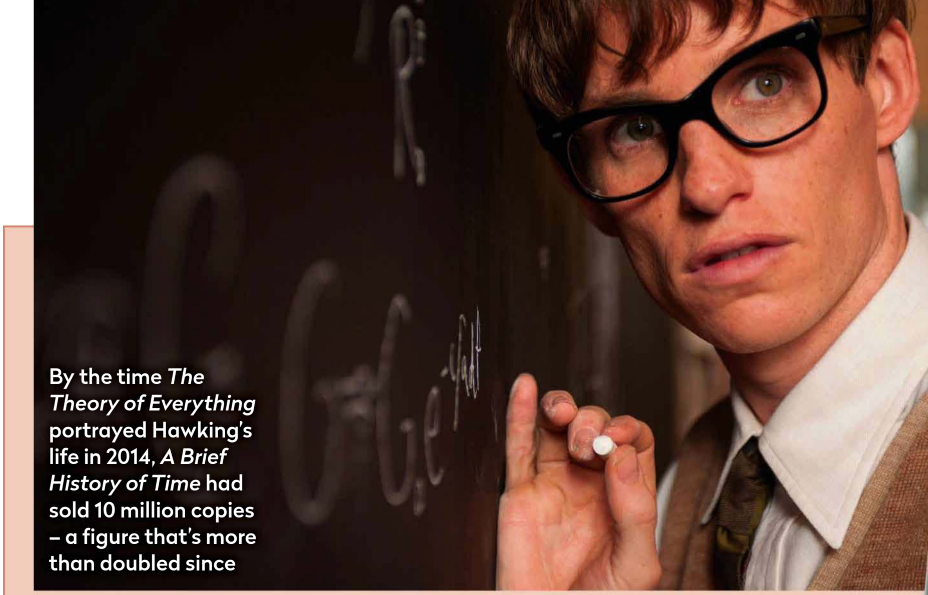
Squashing spacetime

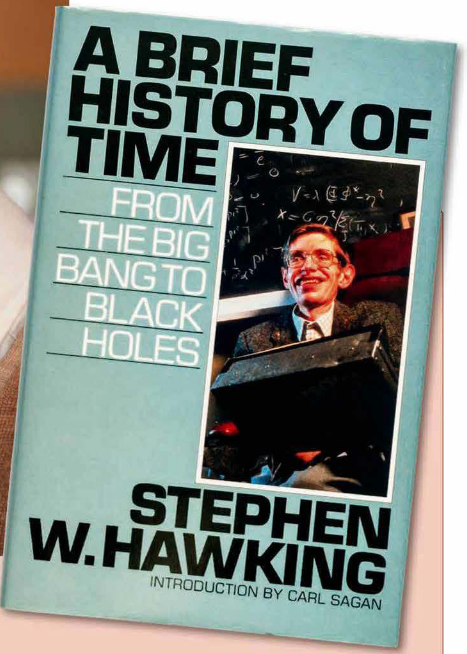
It was a killer breakthrough. In the 1960s, astronomers were still fiercely debating whether the Universe had an origin or whether it had been around forever. Today, most astronomers are happy to concede that the Universe did start with a singularity. Although it usually goes by a far more recognisable name: the Big Bang.

The Big Bang isn't the only place in the Universe where singularities crop up. They also appear at the

▶ **Hawking pictured shortly after the publication of *A Brief History of Time* in 1988**

RUBY/ALAMY STOCK PHOTO, TRINITY MIRROR/MIRRORPIX/ALAMY STOCK PHOTO, TCD/PROD. DB/ALAMY STOCK PHOTO, SJBOOKS/ALAMY STOCK PHOTO, NASA/JPL-CALTECH, GETTY


By the time *The Theory of Everything* portrayed Hawking's life in 2014, *A Brief History of Time* had sold 10 million copies – a figure that's more than doubled since

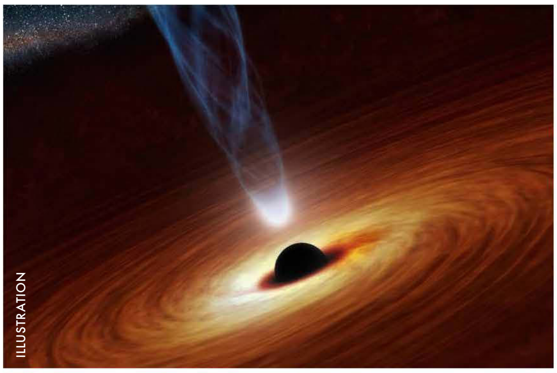


A brief history of education

Hawking's mission to communicate his ideas to the public made him a cultural icon

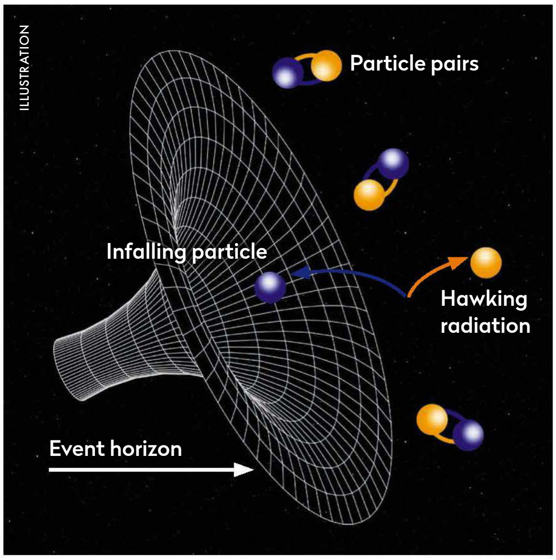
It is one of the most famous popular science books ever written. Since its release in 1988, *A Brief History of Time* has sold over 25 million copies and been translated into 40 languages. It appeared on the *Sunday Times* bestseller list for a record-breaking 237 weeks – although it's famously a book that a lot of people own but few have finished. Hawking's attempt to explain his work on the Big Bang and black holes remains a challenging read for someone with no prior knowledge of astronomy. In the later part of his life, Hawking also wrote children's books alongside his daughter, Lucy.

Very few scientists – if any – have enjoyed the kind of cultural cut-through that Hawking achieved. Eddie Redmayne won the Oscar for portraying Hawking on the silver screen in *The Theory of Everything*. Four appearances in *The Simpsons* and seven in *The Big Bang Theory* helped endear Hawking to millions. This platform allowed him to become one of the foremost science communicators in the world. This legacy continues even now. In 2015, he launched the Stephen Hawking Medal for Science Communication, awarded to those who help promote science to the public through media such as cinema, music, writing and art.



ILLUSTRATION

◀ Hawking proposed that at the centre of black holes are points of infinite density where spacetime itself breaks down – a singularity



ILLUSTRATION

▶ One of his most startling ideas was that black holes lose mass through Hawking radiation

centre of black holes, enigmatic objects forged when the most massive stars die. As the core of the star collapses, spacetime is squashed down into a singularity.

Hawking spent a lot of time thinking about black holes, particularly an idea now known as Hawking radiation. In the sub-atomic world, pairs of ghostly particles are constantly popping into existence before recombining and disappearing again. Hawking pictured this process unfolding at a black hole's event horizon – the invisible boundary separating the inside of the black hole from the Universe. One particle would be trapped inside the black hole, forever separated from its partner on the other side of the event horizon. Unable to recombine and disappear, the mass of a black hole will decrease as it constantly loses one half of the particle pairs. In other words, Hawking showed that black holes are slowly evaporating.

While a convincing argument, astronomers have yet to spot Hawking radiation. It's perhaps why, surprisingly, Hawking was never awarded a Nobel Prize. His long-time collaborator, Roger Penrose, did win one in 2020 and maybe Hawking would have shared in the prize too had he lived.

But Hawking died in 2018, at the age of 76 – a remarkably long and extraordinary life for a man diagnosed with motor neurone disease at the age of just 21. Fittingly, Hawking's ashes are buried in Westminster Abbey, not far from the grave of Isaac Newton. The headstone depicts the mathematical equation that describes Hawking radiation.

Colin Stuart (@skyponderer) is an astronomy author and speaker. Get a free e-book at colinstuart.net/ebook

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

How to polar align your mount

Don't skip this essential step to accurately track targets and capture long exposures

Software will help you line up your gear precisely with Earth's rotational axis

EAF
Reducer

If you're an astrophotographer, polar alignment is a crucial step because it ensures your mount can accurately track the stars as Earth rotates, meaning they stay sharp and round during long exposures.

Polar alignment involves aligning the mount's polar axis with Earth's rotational axis, keeping the object you're imaging central in the field of view. The longer your focal length and exposure time, the more precise your polar alignment needs to be, because the narrower field of view at longer focal lengths will magnify tracking errors. Even a minor misalignment can cause star trailing at high magnifications.

While traditional manual polar alignment using a polar scope is often effective, it can also be uncomfortable or awkward when you are craning your neck to look through a polar scope. Using polar-alignment software allows you to take full advantage of your equipment's capabilities, save time and capture longer exposures without star trailing.

There are quite a few software programs that offer polar-alignment capabilities, including NINA, Astro Photography Tool and iPolar by iOptron. We're going to run through how to use SharpCap, a capture tool for various types of astrophotography that supports a wide range of cameras and webcams. Other features include live stacking and image sequence planning.

ALL PICTURES: JIM OWEN

Jim Owen is a UK astrophotographer with a passion for capturing galaxies and nebulae

SharpCap's polar alignment works by first analysing two pictures taken of the area near the pole, then determining the exact area of sky in each image via plate solving. It then calculates the centre of rotation.

Precision approach

Along with following the main steps outlined here, it's important to maintain a 0.5°–2.5° field of view and to aim to have at least 15 stars in view. If you encounter difficulties, adjust your camera settings or fine-tune your star-detection parameters.

It's also crucial to click the 'Next' button to transition to the adjustment stage before making any changes to your mount's position. Remember that you need to be within 5° of the pole for the alignment to be effective, which can be achieved through the initial rough polar alignment using a compass in Step 1. Keeping these points in mind, you can significantly improve the accuracy and efficiency of your polar alignment process.

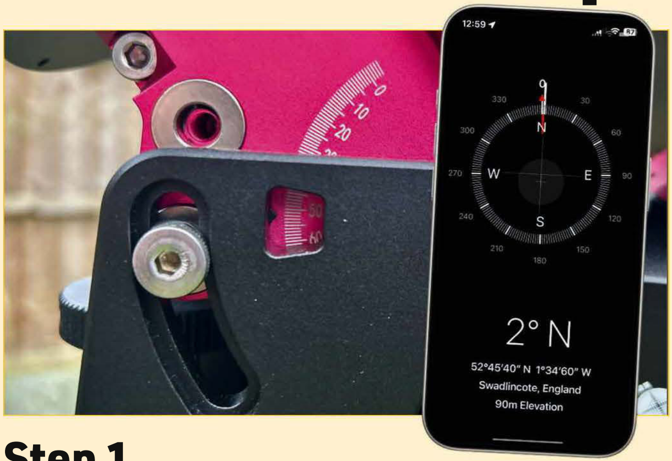
In addition to increased precision, using polar-alignment software speeds up an often fiddly process. Even better, if you use a sensitive guide camera it will allow you to detect faint stars and 'see through' light pollution – a common issue for astronomers today. This is unlike traditional polar scopes, which rely on our eyes.

By mastering polar alignment, you can significantly enhance the quality of your astrophotos. Varying levels of polar alignment are available across SharpCap's free and Pro software versions; while you can test your polar-alignment accuracy without a licence, SharpCap Pro is required to use the adjustment stage of the tool that guides you to correct alignment.

What you'll need

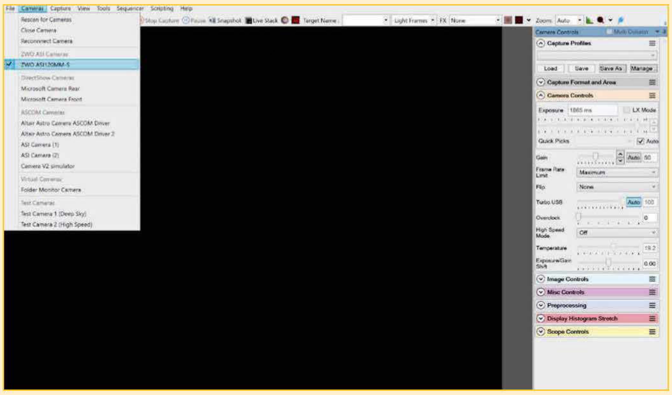
- ▶ An equatorial (EQ) mount
- ▶ SharpCap Pro license (£14 per year)
- ▶ Compass
- ▶ A camera with a 1/3-inch (4.8mm x 3.6mm) sensor supported by SharpCap
- ▶ A guidescope that provides a field of view for the camera of about 0.5°–2.5° – a focal length of 120mm–250mm typically works well

Step by step



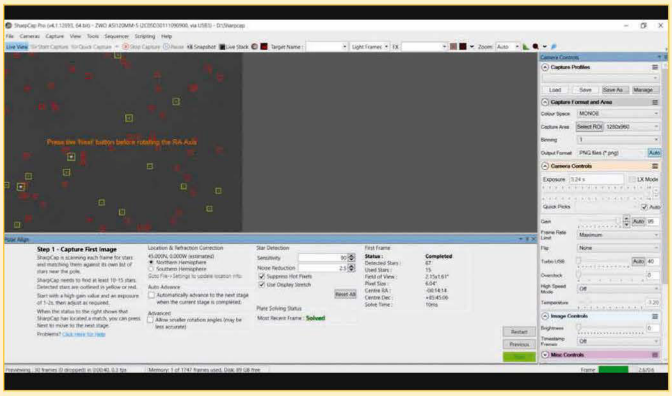
Step 1

Roughly polar align. Using a compass, point your mount towards the pole for your hemisphere; in the Northern Hemisphere, this is Polaris, the North Star. Set the mount's latitude for your location (drop a pin on the map at www.latlong.net to find out yours).



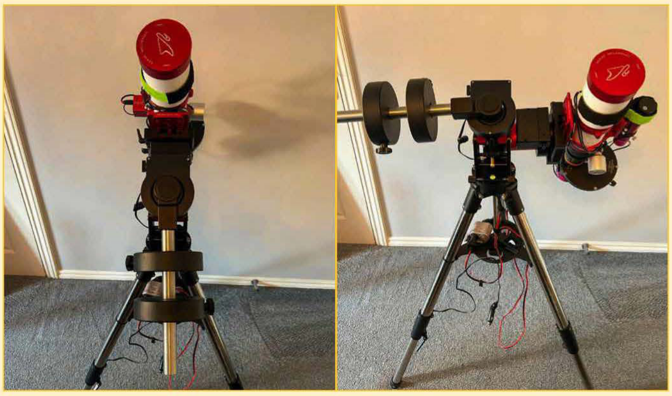
Step 2

Launch SharpCap, connect your camera via the Cameras menu and use 'Auto image' or set a long exposure to capture at least 15 stars. If needed, adjust the gain setting to increase the sensitivity of the camera to allow it to detect more stars.



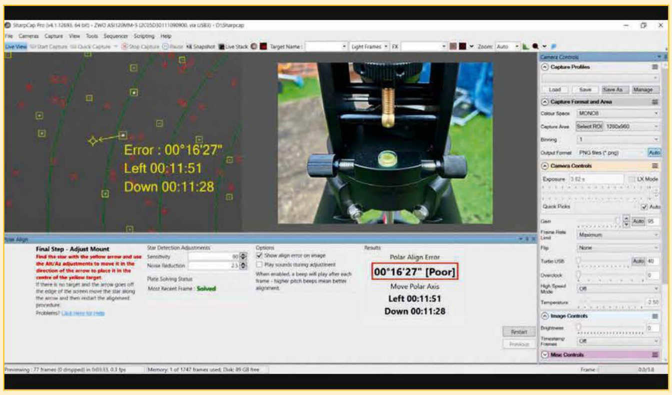
Step 3

Navigate to 'Tools' and click 'Polar Align'. The software attempts to plate solve the guide camera's image. If your camera's view is wide enough and your mount is pointing towards the pole, SharpCap will automatically examine and solve the image.



Step 4

When prompted, unlock the RA clutch and rotate your telescope 90°. SharpCap will continue capturing frames. Rotation provides a wide separation between the two imaging positions, increasing the accuracy of the alignment; 90° gives the best accuracy.

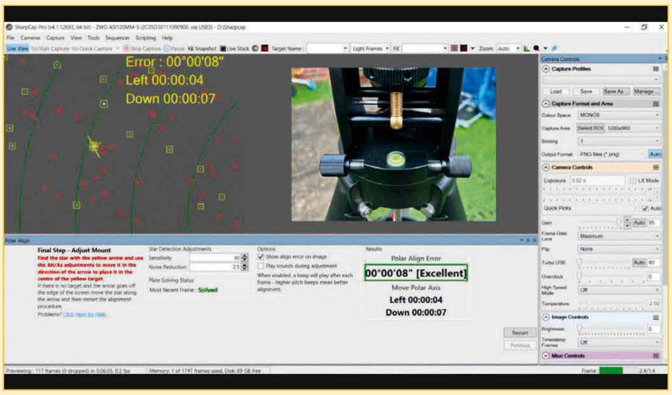


Error : 00°16'27"
Left 00:11:51
Down 00:11:28

Polar Align Error
00°16'27" [Poor]
Move Polar Axis
Left 00:11:51
Down 00:11:28

Step 5

SharpCap monitors the rotation process during polar alignment. If the rotation stage fails, it's typically due to insufficient rotation of the mount or an accidental nudge. SharpCap will display an error message and you'll need to restart the process.



Error : 00°00'08"
Left 00:00:04
Down 00:00:07

Polar Align Error
00°00'08" [Excellent]
Move Polar Axis
Left 00:00:04
Down 00:00:07

Step 6

To get perfect alignment, use the altitude and azimuth bolts on the side of your mount to make tiny adjustments. The SharpCap software will guide you by showing you on the screen exactly which way to turn the bolts to achieve the best alignment.

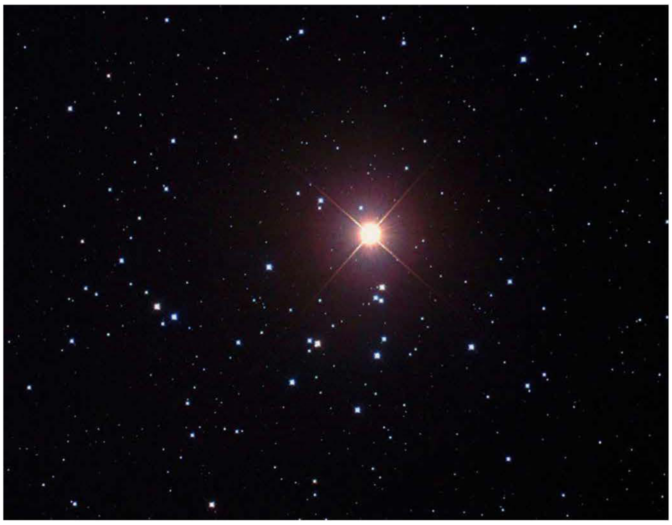
Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Mars in the Beehive

How to photograph the Red Planet among the stars of magnificent M44 in early May

We've mentioned Mars crossing the Beehive Cluster a few times in this issue (see page 46) and for good reason. Mars is bright and easy to find and, atypically for most deep-sky objects, the Beehive is bright and large too. This means it's an event that can be enjoyed by many, even if you don't have specialist kit. Binoculars will show the passage beautifully.



▲ **Mars will pass through the northern section of the Beehive Cluster, M44, at the start of May, a great opportunity to hone your photographic skills on an iconic deep-sky cluster**

In terms of photographing the crossing, the Beehive is quite photogenic, showing up in low-image-scale shots as a fuzzy patch. A bit of focal length is required to show the main stars nicely separated, but you don't need a lot. As a consequence, with a camera set to high sensitivity, it's possible to grab a shot of the cluster without tracking. Just remember the '500 rule': your longest non-trailed exposure (in seconds) is 500 divided by your setup's focal length (in millimetres). So, for a 200mm lens, you can expose for 2.5 seconds without star trails becoming noticeable.

Watch out for field rotation

For those who have smart telescopes, the passage is an easy one to record, but there are still pitfalls to avoid. Most smart scopes operate in altaz mode, which means their images are subject to an effect known as field rotation. Basically, if you image over a long period of time, the imaging frame appears to rotate around the centre of the image. The onboard live stacking routines compensate for this, but you'll see evidence of it in the extreme corners of the image frame.

Some smart scopes offer an equatorial mode. This allows you to tilt the scope like you would a regular equatorial telescope mount, so the azimuthal axis becomes parallel with Earth's axis of rotation. If your smart scope doesn't have an equatorial mode, this may confuse it, although many have been able to overcome the confusion, so a bit of research may work wonders.

Then there's the target you select. If you plan to image Mars crossing the Beehive over several evenings, the planet is no slouch and will zip in and out of the cluster over just a few days. Choosing to centre on Mars will mean the overlaps of the stars that you'll need to capture (in order to put together a composition that shows the movement of the planet) may be quite wide. Miss a day or two because of cloud and you might not have any overlap at all.

If your device has a mosaic option, this can be used to create a larger image of the Beehive and surrounding area that can act as a reference for your final composition. Of course, if you're using a regular camera and telephoto lens or a driven telescope, the issue is less of a problem, as long as you use a focal length sympathetic to the target area.

Mars is no stranger to the Beehive and you'll not be recording anything new or groundbreaking here. However, not all passages are well timed, sometimes occurring when twilight interferes. For this month's conjunction, the planet passes in front of the cluster under dark-sky conditions and that's certainly worth making the effort for.

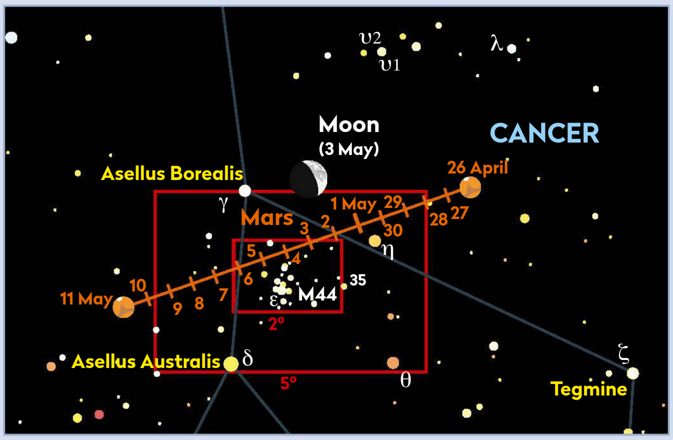
Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: camera, 135mm lens or larger, telescope or smart telescope

✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

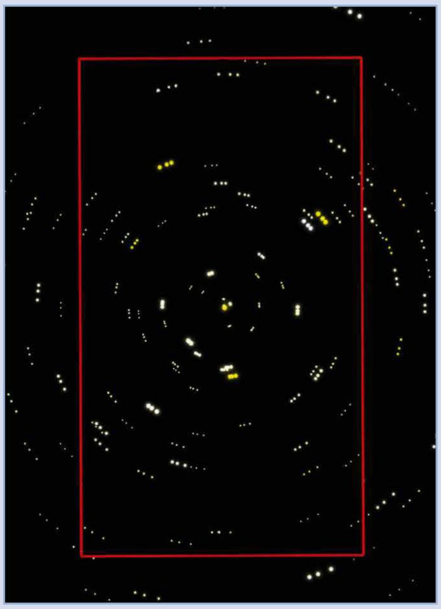


STEP 1

Decide how many evenings you want to try and capture for. Mars is currently moving at an apparent speed of 0.5° per day and the apparent size of M44 is around 1.5°. A field of view approximately 5° wide gives a nice overview of the event, but 2° will get you closer to the action and require fewer evenings' coverage.

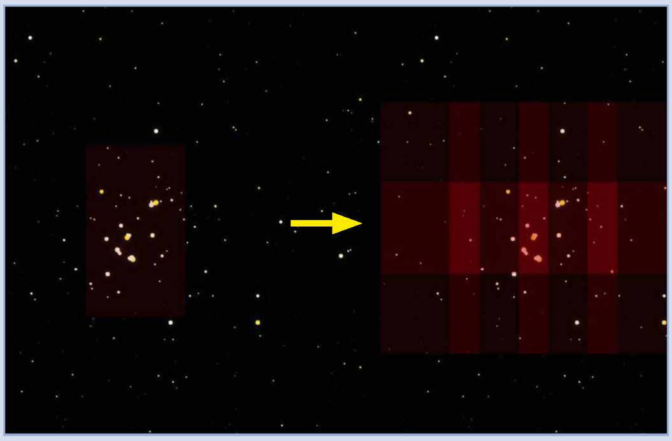
STEP 2

Factor in weather prospects; cloudy evenings may badly affect a planned long sequence. Once you've chosen your coverage area, pick your lens or scope. For a DSLR or equivalent, align the frame so Asellus Borealis and Asellus Australis (Gamma and Delta Cancri) are approximately parallel to the shorter sensor edge.



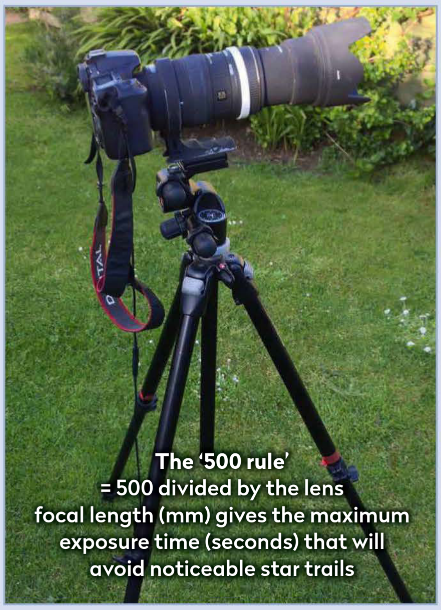
STEP 3

Imaging at the same time of evening, minus four minutes for each night that passes, will remove field rotation effects. For example, if you start at 23:00 on day one, start at 22:56 on day two, 22:52 on day three, and so on. Field rotation is a characteristic of altaz mounts, making the imaged star field appear to rotate around the centre of the frame.



STEP 4

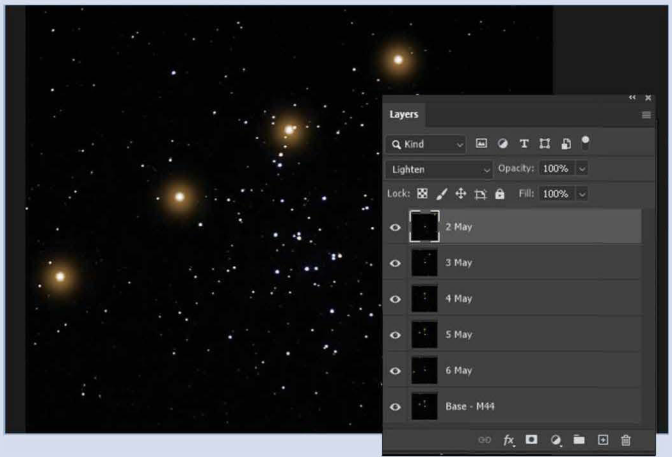
Some smart scopes offer a limited field of view. One solution is to pre-image a larger area in overlapping panels then stitch them together, an option offered by some smart scope control apps. We recommend covering the whole of M44 plus a decent margin around the cluster, to give your composition room to breathe.



The '500 rule'
= 500 divided by the lens
focal length (mm) gives the maximum
exposure time (seconds) that will
avoid noticeable star trails

STEP 5

Plan on capturing Mars every evening that it passes through the area you're covering. The UK's weather rarely plays ball for such ventures, but you might get a gap or two. If you're using a camera on a fixed tripod, maintain exposures below 500/focal length seconds. For tracked devices, use lowish ISO values and extend exposures to give you a good number of faint stars.



Layers

Lighten
Opacity: 100%
Lock:
Fill: 100%

2 May
3 May
4 May
5 May
6 May
Base - M44

STEP 6

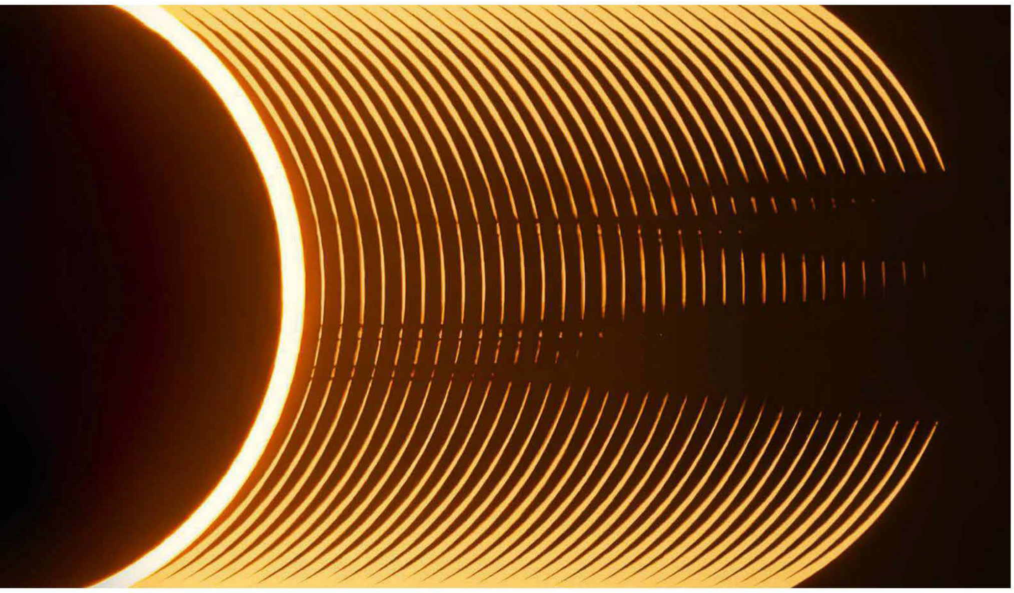
Once you've collected all of your images, pick the best version or mosaic of M44 to use as the base image. Add the Mars images as additional layers in a layer-based editor. Adjust the upper layers so the stars align with the base, then set the upper layer's blend mode to Lighten to reveal Mars passing across the Beehive.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

A unique view of Baily's beads

This award-winning eclipse sequence reveals the Moon's rugged peaks



▲ **Ryan's winning image, showing the progression of Baily's beads during an annular eclipse**

Astronomy Photographer of the Year Advice from the Overall Winner of 2024's competition

An annular solar eclipse offers a rare chance to capture the famed 'ring of fire'. Taken a step further, you can capture a sequence of photos as the Moon moves into and out of the eclipse, ultimately revealing a silhouette of the lunar surface. This shadowy effect is created by gaps that appear between 'Baily's beads', spots of sunlight that form as the Moon's rugged surface rapidly moves across the Sun's edge.

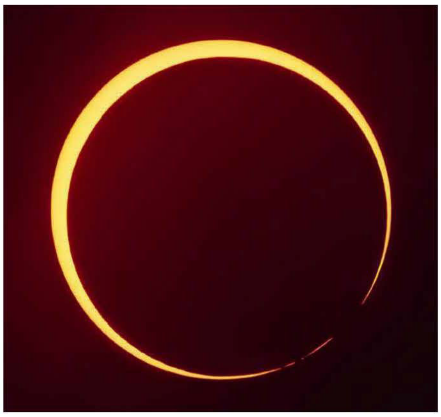
Here I'll describe how I produced an image like this, 'Distorted Shadows of the Moon's Surface Created by an Annular Eclipse', which won 2024's Astronomy Photographer of the Year competition. It offers a unique glimpse of the Moon's topography, thanks to Bailey's beads, during the October 2023 annular solar eclipse. Visible in a 10- to 15-second window, you need to set the camera to continuous burst mode at its highest possible frame rate to capture these beads. I took 34x 1/1000-second exposures with a Nikon D810 camera and a Sigma 150–600mm telephoto lens fitted with a solar filter. My start image (right) shows one of these single frames.

Before starting the processing, I imported my photos into Adobe Lightroom and sorted them by capture time. I also identified my base image, which was a single frame of the maximum phase of the eclipse. With all my images selected, I opened them by choosing File › Open as Layers in Photoshop.

Next, I aligned all frames to the base layer, selecting all the layers (Ctrl + Alt + A) and changing the blending mode from Normal to Difference. I disabled the visibility of all layers except the base layer and a single layer which includes beads (Screenshot 1). Using the Move tool, I adjusted the beads layer until the portion of Sun was completely dark, repeating this step for each layer, ensuring only the layer I was moving and the base layer were visible. Aligning all layers with only the base layer minimises any inconsistencies.

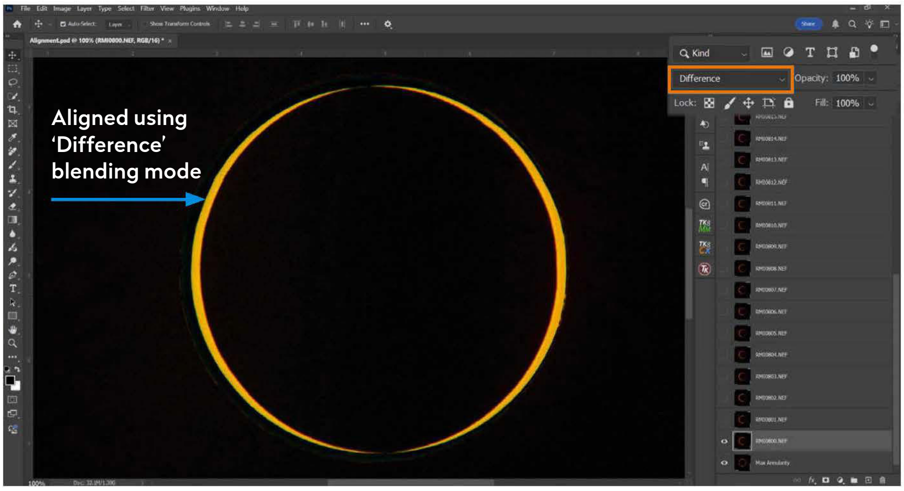
Next, I rotated the layers so that the sequence of beads would progress from left to right. With all layers selected, I clicked Edit › Transform › Rotate to rotate the image until the beads were positioned on the right side of the ring, pressing Enter to apply the rotation to all selected layers.

Each layer now needed to be spaced evenly, showing only half of the ring with Baily's beads. First, I changed the blending mode of all the layers to Lighten.

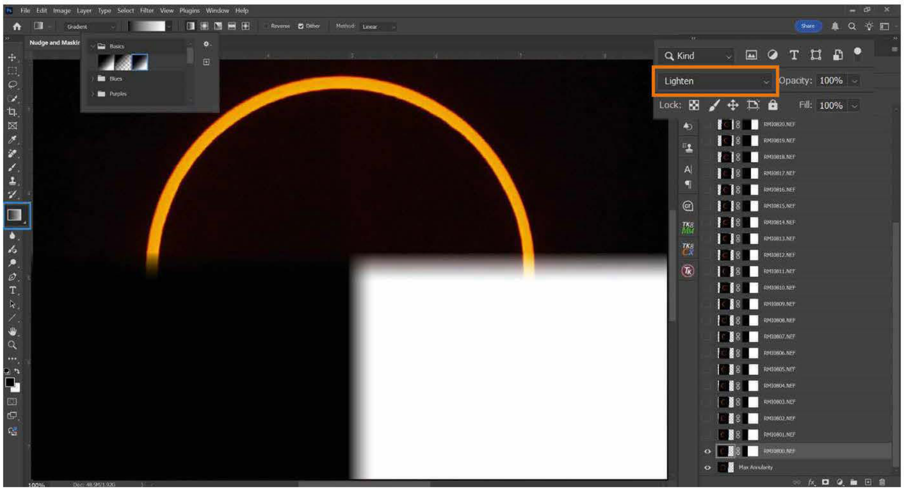


▲ **A single frame showing Baily's beads (bottom right) as sunlight is blocked by lunar mountains while glimmering through valleys and craters**

ALL PICTURES: RYAN IMPERIO


Aligned using 'Difference' blending mode
Kind
Difference
Opacity: 100%
Lock:
Fill: 100%

▲ **Screenshot 1: Photoshop's Difference blending mode allows you to view the alignment between two layers. Since the Moon shifts between shots, it will remain visible**


Kind
Lighten
Opacity: 100%
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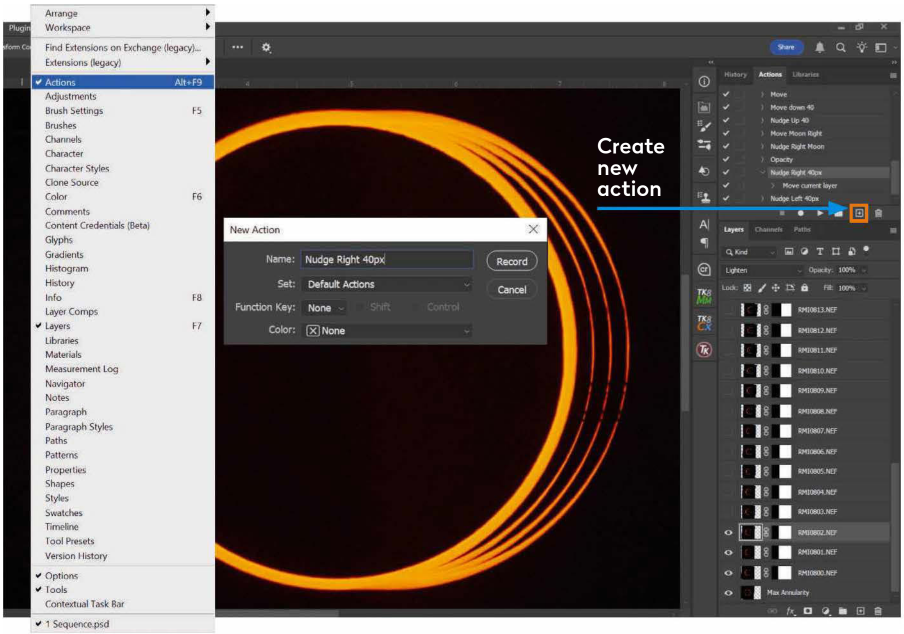
Fill: 100%
Basics
Blues
Purples

▲ **Screenshot 2: change the blending mode of all layers to Lighten. After applying a layer mask, use the Gradient tool to create a basic linear gradient within the centre of the ring**


Create new action
Arrange
Workspace
Find Extensions on Exchange (legacy)...
Extensions (legacy)
Actions Alt+F9
Adjustments
Brush Settings F5
Brushes
Channels
Character
Character Styles
Clone Source
Color F6
Comments
Content Credentials (Beta)
Glyphs
Gradients
Histogram
History
Info F8
Layer Comps
Layers F7
Libraries
Materials
Measurement Log
Navigator
Notes
Paragraph
Paragraph Styles
Paths
Patterns
Properties
Shapes
Styles
Swatches
Timeline
Tool Presets
Version History
Options
Tools
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1 Sequence.psd
History
Actions
Libraries
Move
Move down 40
Nudge Up 40
Move Moon Right
Nudge Right Moon
Opacity
Nudge Right 40px
Move current layer
Nudge Left 40px
Layers
Channels
Paths
Record
Cancel

New Action

Name: Nudge Right 40px

Set: Default Actions

Function Key: None

Color: ☒ None

▲ **Screenshot 3: Set up a Photoshop 'action' to record and play back any adjustments, making it easy to nudge multiple layers by precisely the same amount of pixels**

3 QUICK TIPS

1. Move your base layer to the bottom of the layer stack to keep it separate.

2. Align the frames based on the visible portion of the Sun, as the Moon's position shifts between exposures.

3. Experiment with the spacing between layers to achieve either a compressed or distorted effect.

Starting with one bead layer, I applied a layer mask by choosing Layer › Layer Mask › Reveal All. I then selected the Gradient tool (Screenshot 2) and used it to drag a basic black-to-white linear gradient across the central part of the ring. The black area concealed the half which will overlap in the sequence. To copy the gradient mask, I held Ctrl, clicked the mask, then went to the next layer and selected the Layer Masks button. I repeated this for all bead layers.

To separate the layers by 40 pixels, I created a Photoshop 'action' to nudge each layer by this exact number, by clicking Window › Actions › Create New Action and naming it (Screenshot 3). This allowed me to record the adjustment I wanted, to later apply across all layers. Select the first layer in the sequence and manually nudge it 40 pixels using the arrow keys on your keyboard. This will also nudge the linked mask. When finished, I clicked 'Stop Recording'. I now had a one-click action that would move any layer and its mask. Selecting the next layer in the sequence and clicking 'Play Selection' automatically nudged it by 40 pixels. I pressed the button again until the layer became visible, continuing this process for all layers until each one was visible.

My final composited sequence not only highlighted the progression of Baily's beads but also showcased the Moon's distinctive topography at the point of contact during the eclipse. I could then make any final adjustments to the image, such as modifying levels or saturation before flattening the layers and saving.

Ryan Imperio is a US ophthalmic photographer who is drawn to the challenges and awe-inspiring nature of astrophotography

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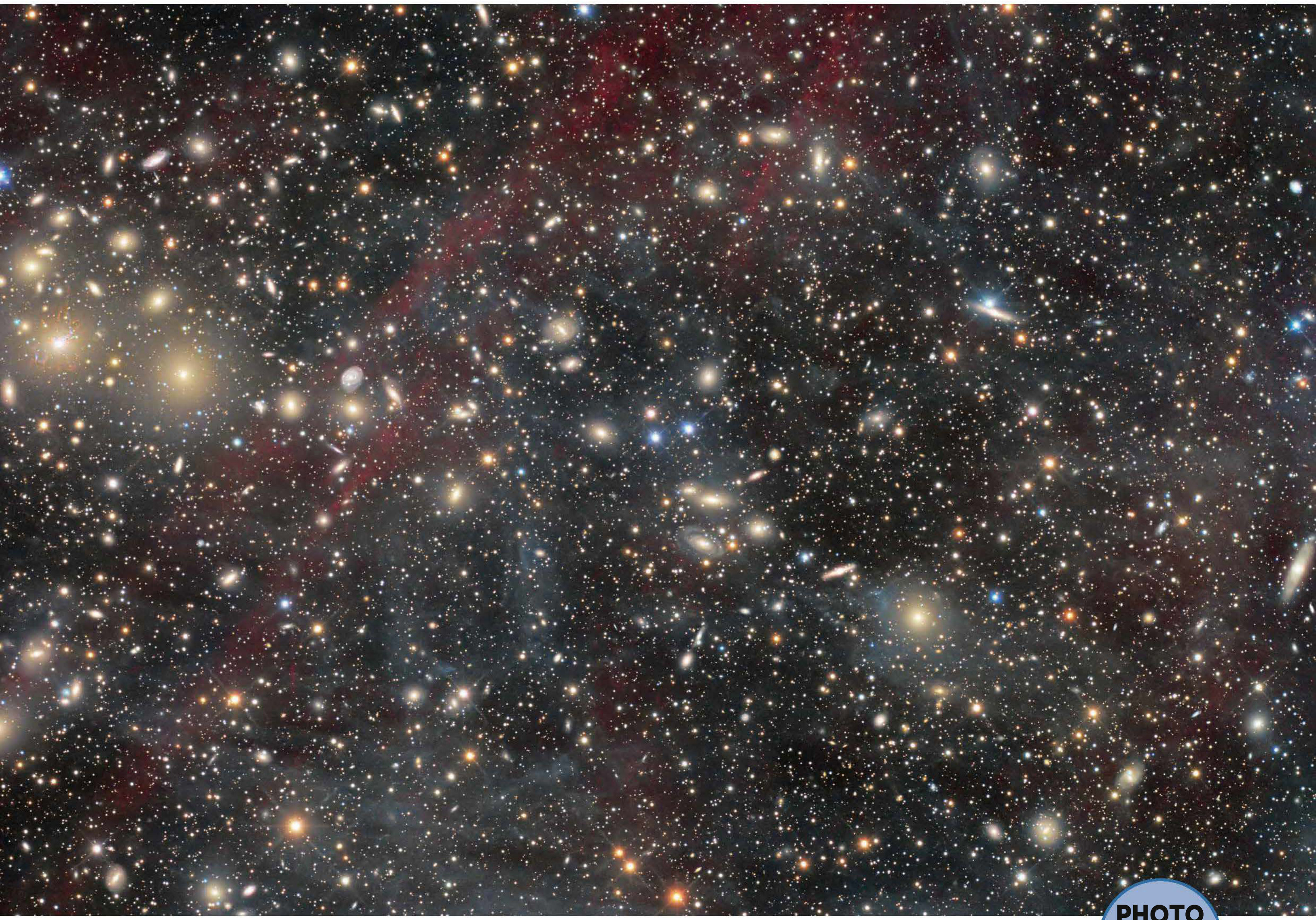


PHOTO OF THE MONTH

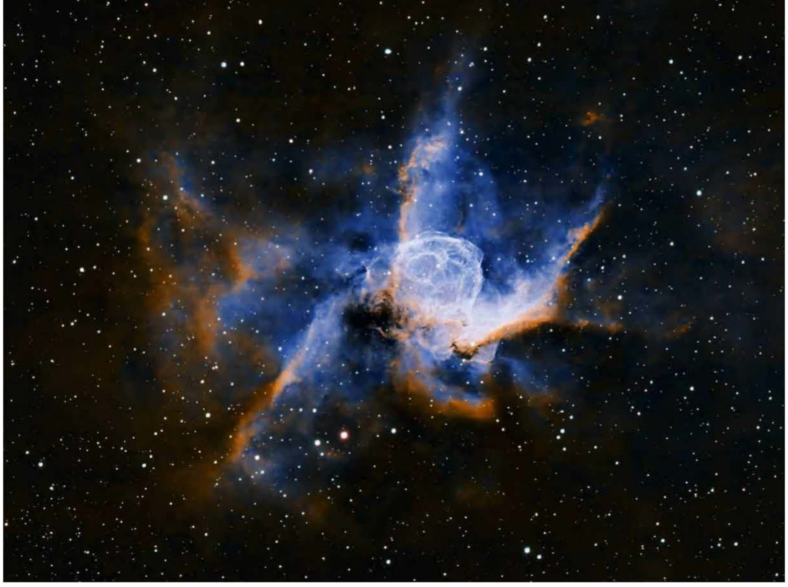
△ The Perseus Cluster

Overall Photons, 19 locations worldwide, 3 November 2024–31 January 2025

Overall Photons say: "Each of the fuzzy blobs in this image is a galaxy, together making up the Perseus Cluster. Most of the data for this was captured under suburban skies with less than ideal light-pollution conditions, but I'd say we pretty much nailed it!"

Equipment: 19 setups, with telescopes ranging from 2.7 inches to 11 inches
Exposure: 392h total
Software: Siril, PixInsight, Photoshop

About the group: "We are a collective of 19 astro imagers located all over the world, but mostly in Europe and the US, who collaborate to achieve hundreds or even thousands of hours of integration on deep-sky targets, trying to create results that are very hard to achieve alone. For us, it's not about creating the most perfect photos; it's about sharing knowledge, helping each other and making this hobby more accessible to everyone."



△ NGC 2359, Thor's Helmet

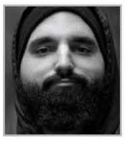
Greg Lynes, Pelynt, Cornwall, 31 January 2025

Greg says: "NGC 2359 has been a dream of mine since taking up astrophotograpy two years ago. There were some challenges involved, but the final image turned out better than I expected."

Equipment: ZWO ASI183MC Pro camera, RVO Horizon 80ED refractor, Sky-Watcher EQM-35 Pro mount **Exposure:** 69x 300" **Software:** PixInsight

▽ Planetary parade

Rui Santos, Pinhal de Leiria, Portugal, 28 February 2025



Rui says: "I chose a familiar location, the Crastinha watchtower. I couldn't get there early enough to have Saturn, Neptune and Mercury in frame, but there was so much more happening, I figured I had to do a panorama."

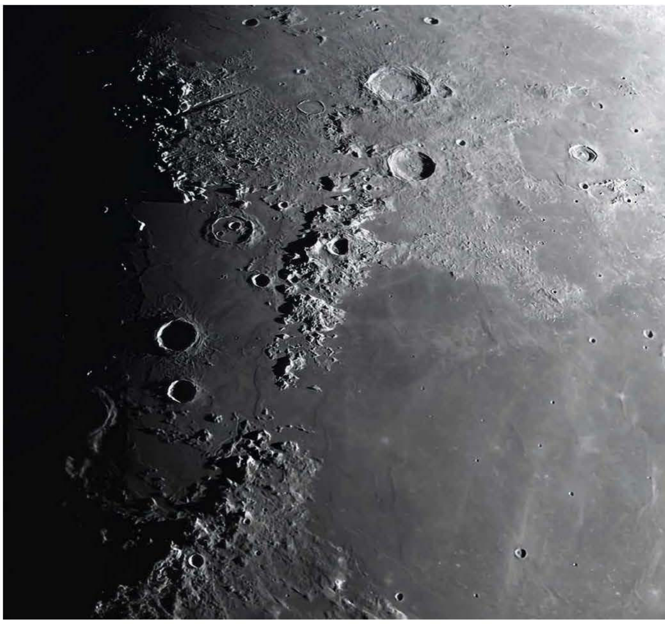
Equipment: Sony A6000 camera, Samyang 12mm lens, Geekoto AT24Pro Dreamer tripod **Exposure:** ISO 6400 f/2.8, 40x 20" **Software:** PTGui, Lightroom, Photoshop, Luminar

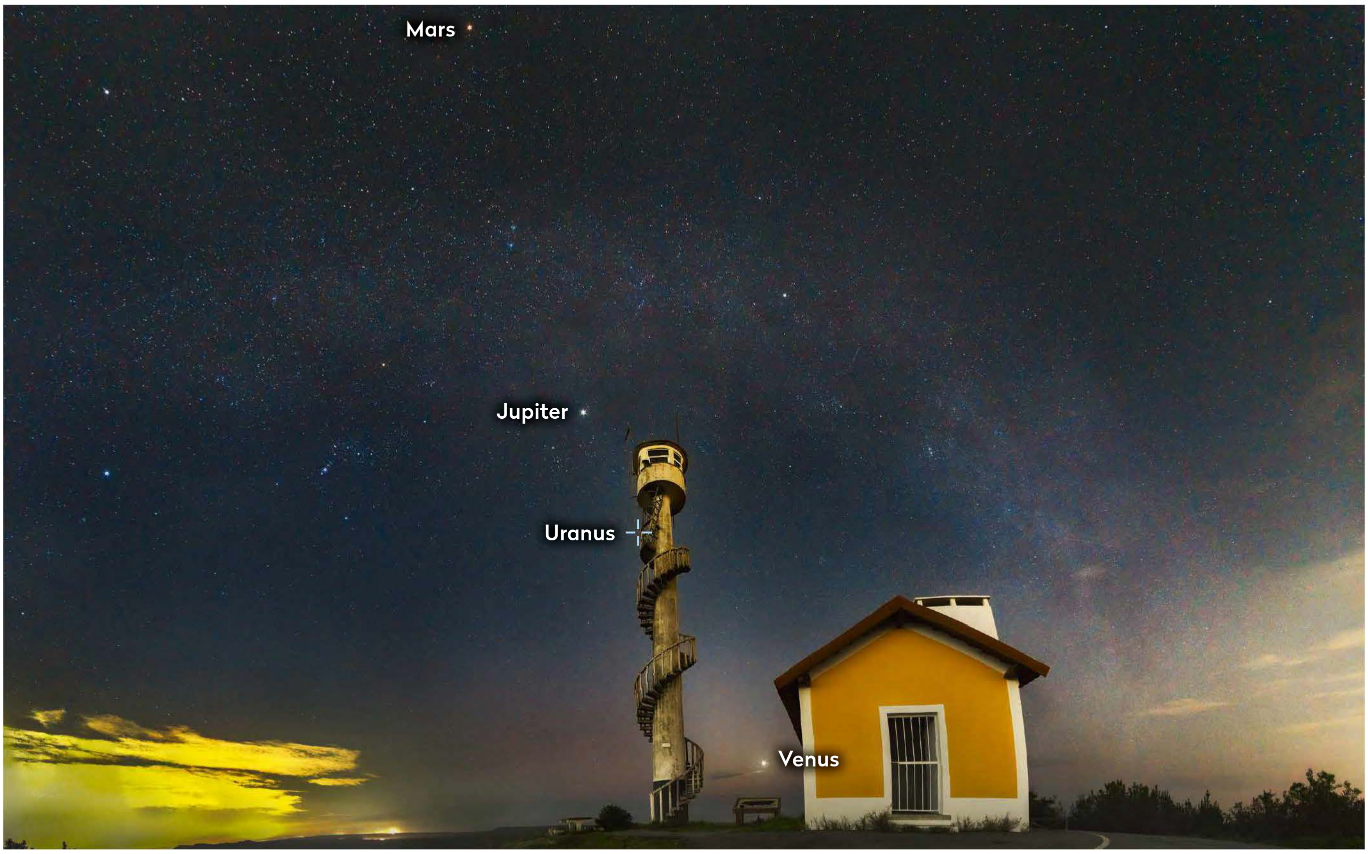
▽ Montes Caucasus and Apenninus

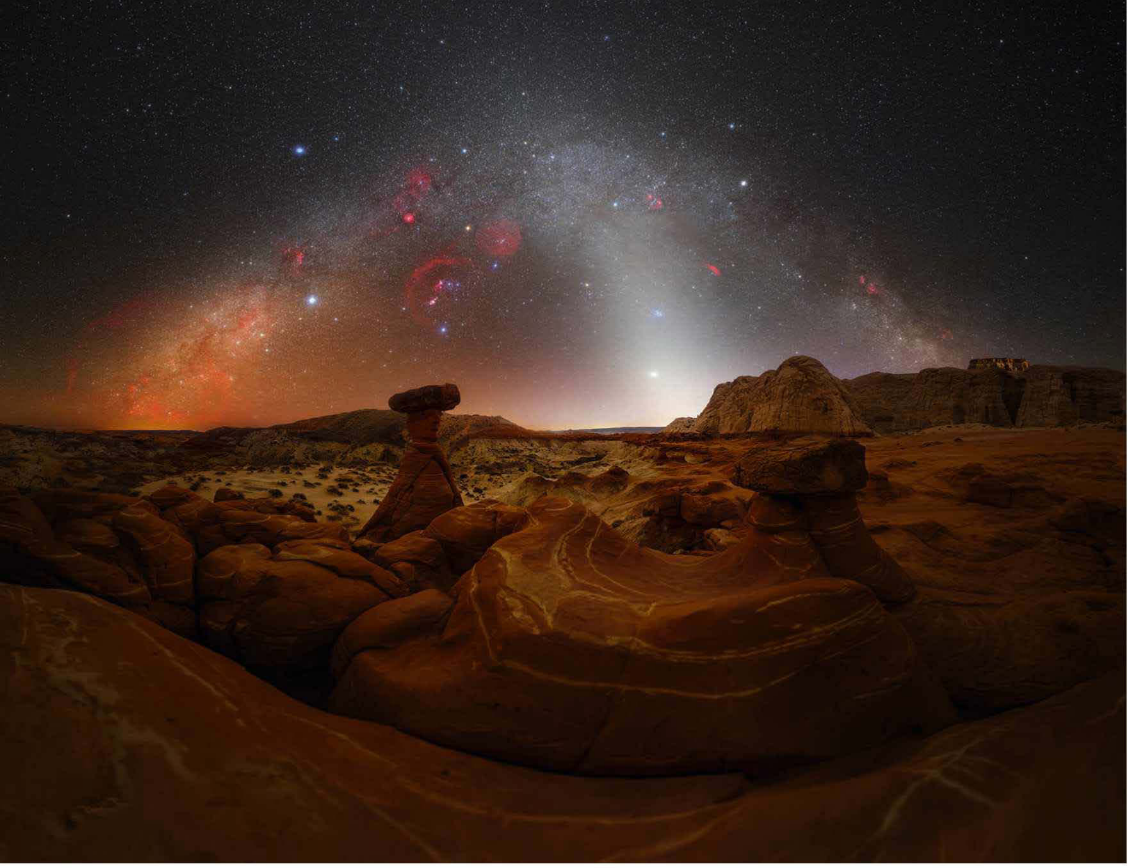
Simon Laverick, Darlington, Co Durham, 8 February 2025

Simon says: "It's amazing what you can capture from a back garden in the northeast of England! I was delighted with the clarity I achieved."

Equipment: ZWO ASI183MC camera, Celestron EdgeHD 8-inch Schmidt–Cassegrain, ZWO AM5N mount **Exposure:** 3x 60" video **Software:** AstroSurface, PixInsight, Photoshop







◁ Milky Way over Utah

Tomáš Slovinský, Kanab, Utah, USA, 3 April 2024

Tomáš says: "This picture shows the winter arc, part of the Milky Way, as seen over the Toadstool Hoodoos rock formation in Utah. If you look closely, you can also spot comet 12P/Pons–Brooks passing close to Jupiter."

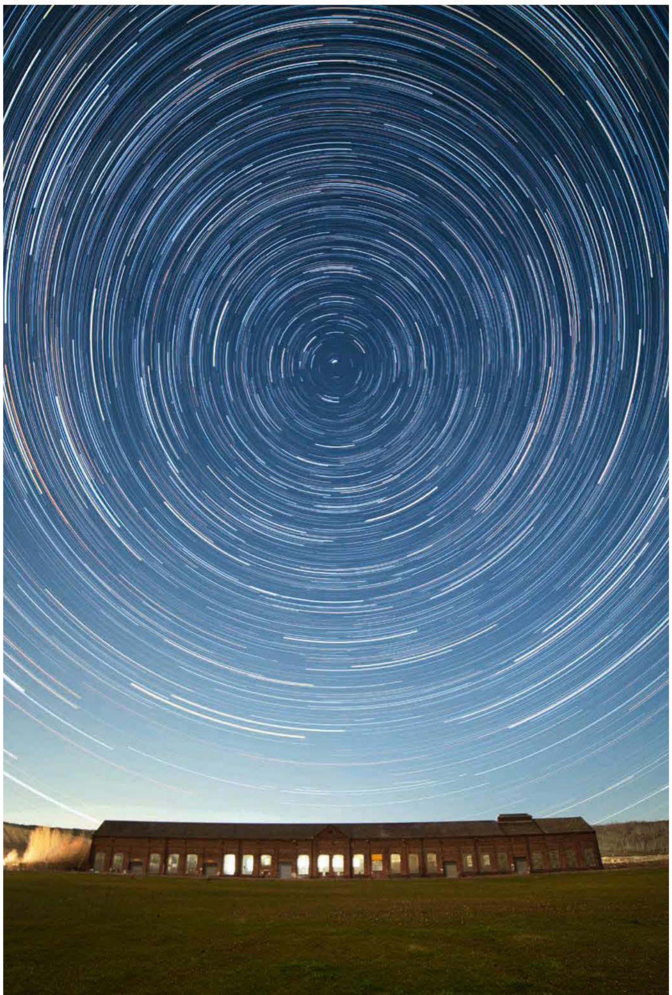
Equipment: Canon EOS R6 camera, Sigma Art 28mm lens, Sky-Watcher Star Adventurer mount **Exposure:** 40x 20" **Software:** Lightroom, Photoshop, PTGui

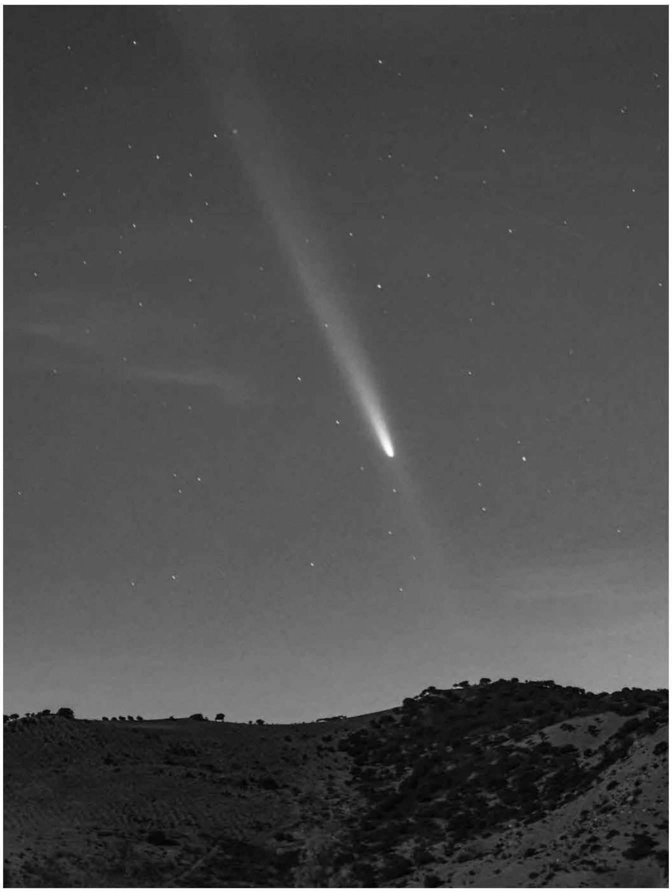
▽ Star trails

Jordan Mawbey, Edwinstowe, Nottinghamshire, 5 February 2025

Jordan says: "I have long admired the historic workshop at the former Thoresby Colliery, and the star trails above captured its timeless, rustic charm beautifully."

Equipment: Canon EOS 6D camera, Samyang 14mm lens, Camolo 75-inch tripod
Exposure: sky ISO 800 f/2.8, 270x 23"; foreground ISO 400 f/2.8, 1x 90"
Software: Lightroom, StarStaX, Photoshop



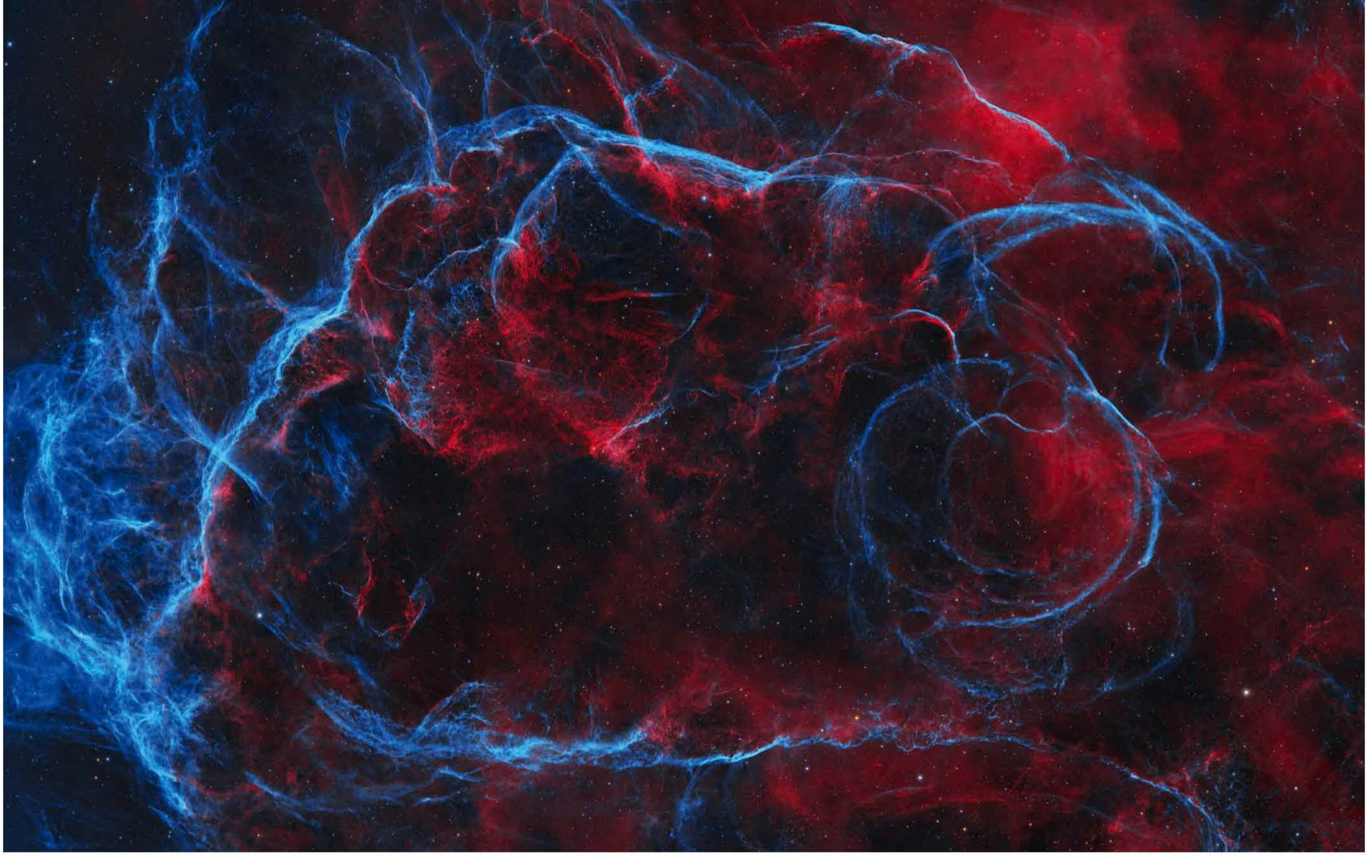


△ Comet C/2023 A3 Tsuchinshan–ATLAS

Teresa Molinaro, Palermo, Sicily, Italy, 14 October 2024

Teresa says: "Photographing a comet was unforgettable – the fulfilment of a dream I'd had for some time. Some light clouds threatened the horizon, but I managed to get the shot I wanted."

Equipment: Fujifilm X-T30 II camera, Fujinon XF18–55mm lens, Cambofoto SAB264 tripod
Exposure: ISO 1000 f/5.0, 13" **Software:** Lightroom

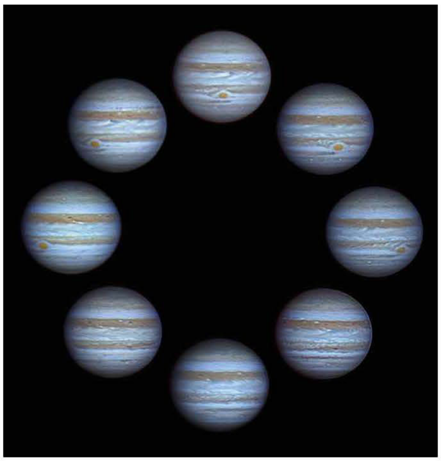


△ Vela supernova remnant

Rod Prazeres, Hillcrest, Queensland, Australia, 5–27 December 2024

Rod says: "This is the new and final version of my Vela SNR project. After just short of 37 hours under Bortle 6 skies, I'm thrilled to reveal the result."

Equipment: ZWO ASI2600MM Pro camera, William Optics RedCat 51 refractor, Sky-Watcher NEQ6 Pro mount
Exposure: RGB 80x 60" each, Ha 82x 600", OIII 115x 600"
Software: PixInsight, Photoshop

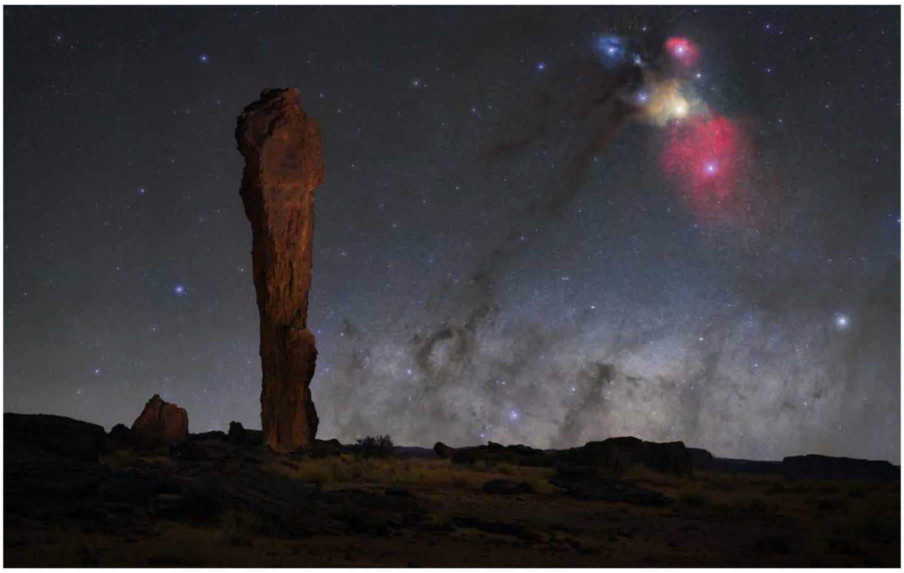


◁ Rotation of Jupiter

Rich Addis, Wallasey, Merseyside, 5 January–4 February 2025

Rich says: "It's fascinating to watch Jupiter's cloud patterns change from one day to the next. Bringing out details with a small scope is a challenge, but it makes the results even more rewarding."

Equipment: ZWO ASI120MC camera, Celestron NexStar 6SE SCT
Exposure: 2,000x 0.01" video (best 1,200)
Software: AutoStakkert!, Photoshop, RegiStax



◁ Milky Way over Ennedi

Vikas Chander, Ennedi, Chad, 5 February 2025

Vikas says: "Rho Ophiuchi is a colourful cloud complex near the Milky Way's core, residing just above the Dark Horse Nebula. A lone stone pillar on the plateau of Ennedi adds mystery and drama to the scene."

Equipment: Sony a7R V camera, Sony 85mm lens, Rainbow Astro RST-135E mount
Exposure: sky ISO 800 f/2.8, 12x 300"; foreground ISO 800 f/2.8, 480"
Software: PixInsight, Photoshop

ENTER YOUR IMAGE

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5
The Story of Astrophysics in Five Revolutions
Ersilia Vaudo
Translated by Vanessa Di Stefano

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Have those mount-making maestros at Sky-Watcher done it again with the new Wave 100i? Find out how it stood up to our testers

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★☆ Very good
★★★☆☆ Good ★★☆☆☆ Average ★☆☆☆☆ Poor/avoid

PLUS: our astro gear picks and books on radical moments in astronomy history, a meteorites memoir, and more...

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Our experts review the latest kit

FIRST LIGHT

Sky-Watcher Wave 100i mount and tripod

Want a whisper-quiet, lightweight and effortless mount? This could tempt you

WORDS: TIM JARDINE

VITAL STATS

- **Price** £1,848
- **Mount type** Altaz/equatorial
- **Load capacity** 10kg
- **Slew speed** Max 10° per second
- **Power input** 12V 2A DC
- **Autoguider port** ST4
- **Protocols** ASCOM, INDI, Stellarium, SkySafari, Cartes du Ciel
- **Weight** 4.3kg
- **Supplier** Optical Vision Ltd
- **Email** info@opticalvision.co.uk
- **www.**opticalvision.co.uk

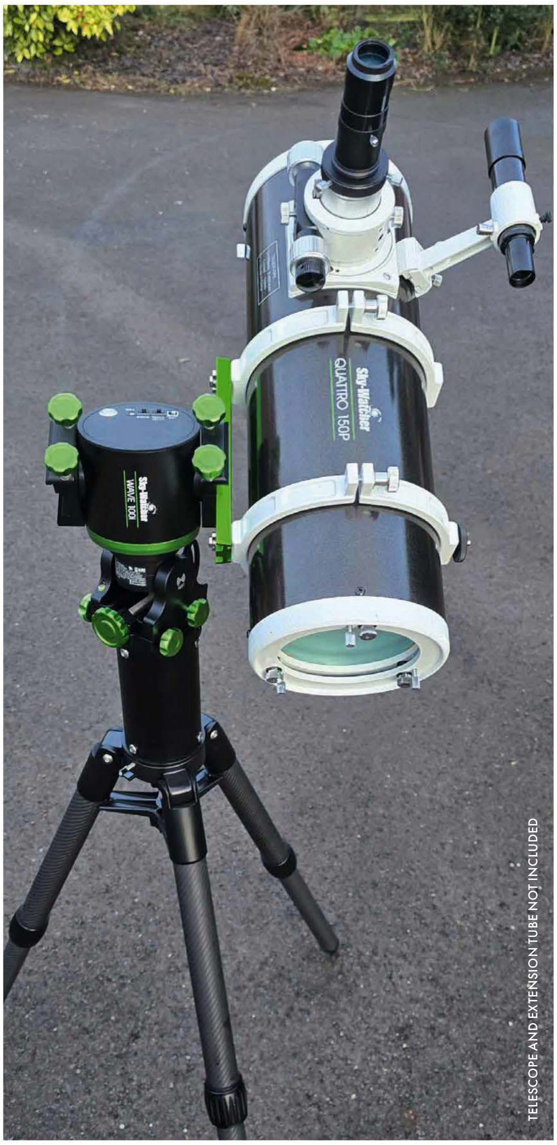
The Sky-Watcher Wave series of telescope mounts is designed with harmonic drive motors, a significant upgrade from traditional worm-gear mounts. Our review model, the Wave 100i, is the smaller of two mounts available and includes the optional carbon-fibre tripod. For convenience, we also received the optional tripod extension tube.

The Wave 100i is designed for easy portable astronomy and, as luck would have it, the perfect opportunity to test it arose soon after it arrived. A local family mentioned how excited they were by media reports of the 2025 planetary alignment due later that evening. We had a 30-minute window to set up the unfamiliar equipment to survey the skies, so there was a little pressure as we didn't want to disappoint the fledgling astronomers.

Thankfully, the Wave 100i's simple design, clear instructions and fast set-up time enabled us to provide the enthusiastic family with their first-ever views of Venus, Jupiter and Saturn. We were impressed by the efficient assembly and capability of the Wave 100i straight out of the box, especially as time spent setting up equipment during rare clear skies is time that could be better spent at the eyepiece or camera.

Time to get Messier

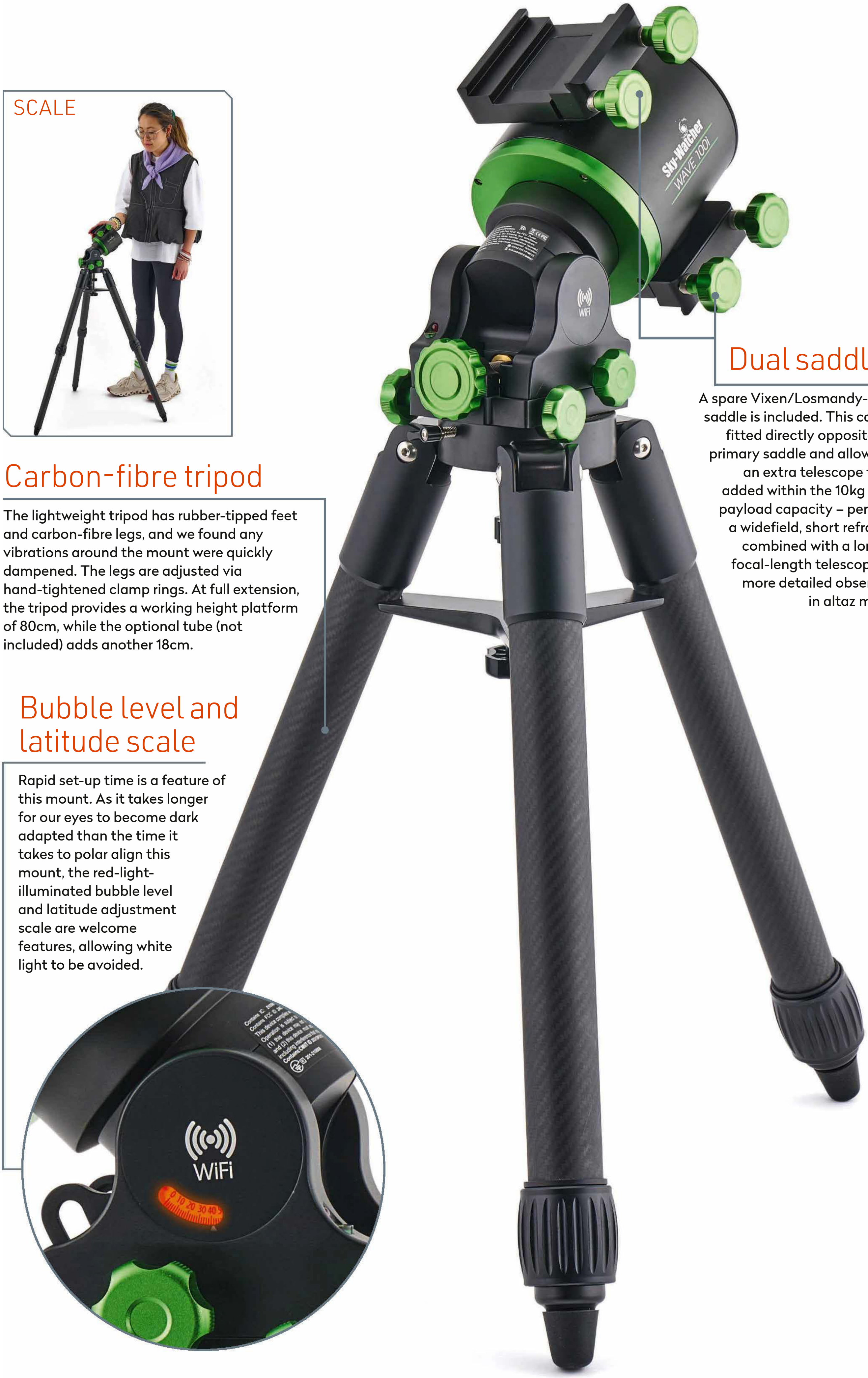
Our next sessions were more formal, with the clear goals of testing the mount in both altaz and equatorial mode, which would include alignment routines, tracking accuracy and performance when linked to a guiding camera. With the mount configured for altaz viewing, we turned it on, noting with approval that the power button is the flat or recessed type, so unlikely to be accidentally activated. There's a cigar-socket-type cable supplied to power the mount, but you'll need your own 12V DC supply with at least 2A capacity.



TELESCOPE AND EXTENSION TUBE NOT INCLUDED

The mount broadcasts its own Wi-Fi signal and once connected to this it can be controlled via several software applications, the simplest of which is the SynScan Pro app for Android or iOS. We chose the 'Brightest Star Alignment' routine as it includes the planets as options. After manually centring two of them in our eyepiece, we set the mount off to explore some Messier objects. ▶

@THESHED/PHOTOSTUDIO X 3, TIM JARDINE



Carbon-fibre tripod

The lightweight tripod has rubber-tipped feet and carbon-fibre legs, and we found any vibrations around the mount were quickly dampened. The legs are adjusted via hand-tightened clamp rings. At full extension, the tripod provides a working height platform of 80cm, while the optional tube (not included) adds another 18cm.

Bubble level and latitude scale

Rapid set-up time is a feature of this mount. As it takes longer for our eyes to become dark adapted than the time it takes to polar align this mount, the red-light-illuminated bubble level and latitude adjustment scale are welcome features, allowing white light to be avoided.

Dual saddles

A spare Vixen/Losmandy-style saddle is included. This can be fitted directly opposite the primary saddle and allows for an extra telescope to be added within the 10kg total payload capacity – perhaps a widefield, short refractor combined with a longer-focal-length telescope for more detailed observing in altaz mode.

FIRST LIGHT

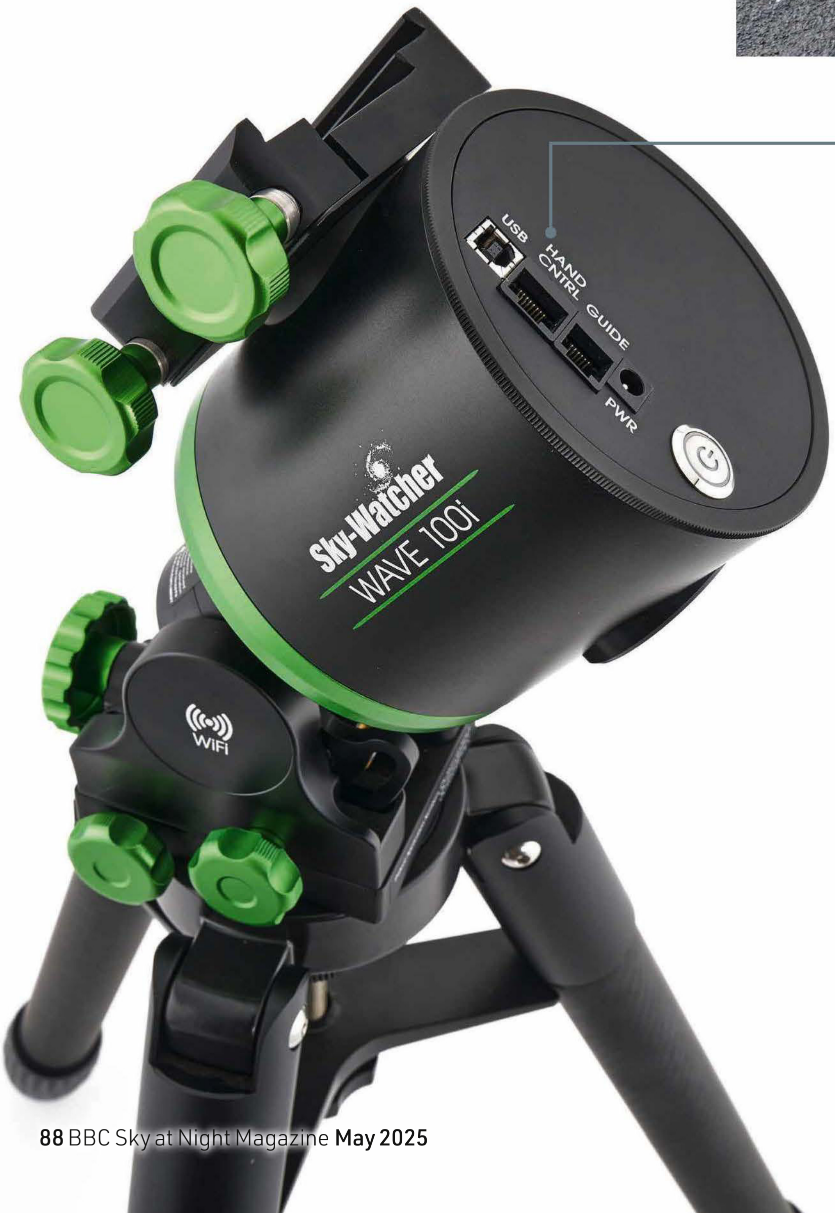
Strong, silent type

The great thing about harmonic-drive-type mounts is their capacity to hold and control equipment that weighs much more than they do. Without any additional counterweights, the 4.3kg Wave 100i can handle up to 10kg of equipment.

Our gear including eyepieces added up to about 6kg and it was deftly swinging around the night sky at a nippy 10° a second with not so much as a murmur. In fact, the Wave 100i is so quiet that at times we had to visually check it was moving. The whole mount assembly, including the steel tripod extension and carbon-fibre tripod, weighs in at a featherweight 7.5kg and is easily lifted with one hand.

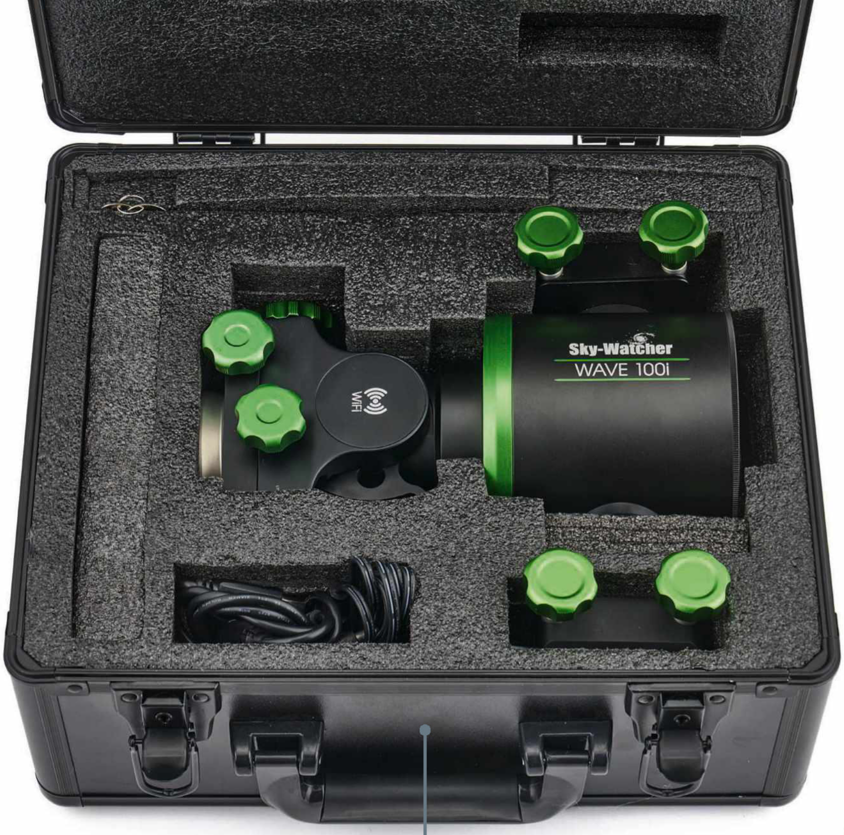
After years of lugging around heavy gear and counterweights, we became an immediate fan of the Wave 100i, especially once it proved capable and accurate. The wireless control via the phone app avoids the need for a handset too, although you can add one if desired, while an optional counterweight kit can take the carrying capacity up to 15kg.

TELESCOPE AND EXTENSION TUBE NOT INCLUDED



Input ports

Connectivity to the Wave 100i is excellent. In addition to control via Wi-Fi or Bluetooth, there are USB, ST4, hand controller and power ports. These are positioned on the top of the mount, which is convenient. However, we felt rubber caps or similar could be useful to help keep dew out of the connections.



Carry case

The mount head comes with a stylish hard carry case plus foam lining with various cut-outs for accessories. The 12V DC cigar-socket-type power cable and the USB cable for PC control stow away neatly, along with a pair of Allen keys and bolts for fitting the extra saddle.

Sky-Watcher
WAVE 100i
WiFi

▶ As expected with Sky-Watcher products, the Wave 100i accurately dropped onto our selected targets, the Orion Nebula in the south and Bode's Galaxy in the north, and happily settled on Jupiter, Venus, Mars, Uranus and Neptune as requested, in each case landing the target within the field of our 12mm eyepiece. When left alone to track a target over an extended period, the mount behaved admirably; the altaz tracking mode held Jupiter dead centre for over an hour.

Using the Wave 100i in equatorial (EQ) mode involves adjusting the angle at which the mount sits to match the latitude of the observing location. Adjustable between 0° and 90°, this portable mount is useable anywhere on the globe, from equator to pole. Accuracy in EQ mode requires the mount to be aligned with the celestial pole.

Silky-smooth tracking

After a two-star alignment routine, there's the option to polar align the mount via the SynScan app. The instruction manual, which is available via download, advises repeating the polar-alignment process a few times to increase accuracy, which we did. The whole routine of star and polar alignment only took us around 10 minutes: an impressively fast workflow. The Wave 100i was equally capable at locating and tracking targets in EQ mode, so we were keen to see how it responded when it was hooked up to an autoguide camera for astrophotography.

Using the ST4 guide port on the mount, we attached our camera and via PHD2 software locked on to a relatively fast-moving star within Messier 45. It was reassuring to see the PHD2 guide graph showing stable and smooth guiding adjustments, perfect for mobile astrophotography.

The Wave 100i enabled us to enjoy portable visual astronomy with minimal fuss and it makes the goal of simple travelling astrophotography easier to achieve.

VERDICT

Assembly	★★★★★
Build & design	★★★★☆
Ease of use	★★★★★
Go-To/Tracking accuracy	★★★★★
Stability	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Sky-Watcher Wave extension tube

2. Sky-Watcher Wave counter-weight kit

3. Sky-Watcher SynScan hand-set and cable

@THESHED/PHOTOSTUDIO X 4, TIM JARDINE

Our experts review the latest kit

FIRST LIGHT

Altair 678C colour USB3 astronomy camera

A fast-frame-rate, high-sensitivity option for imaging the Moon and planets

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £259
- **Sensor** Sony IMX678 Starvis 2 CMOS
- **Resolution** 8.3MP, 3,840 x 2,160
- **Exposure range** 0.1ms–1,000 seconds
- **Connectivity** USB 3.0, USB 2.0
- **Size** 37mm x 72.4mm
- **Weight** 70g
- **Supplier** Altair Astro
- **Tel** 01603 721946
- **www.altairastro.com**

Altair Astro has recently added two new cameras to its GPCAM3 range: the colour 678C and the 678M, its monochromatic sibling. Both are fitted with the latest Sony IMX678 Starvis 2 CMOS sensor that promises to deliver excellent 'lucky imaging' capability – perfect for the planetary imaging game. With an array of planets peppering the early 2025 skies, it was the ideal time to put the Altair 678C through its paces.

Unpacking the 678C, we found a small yet striking camera in Altair's signature purple colour. Weighing in at 70g and only 72mm in length, the body is barely larger or heavier than a 1.25-inch Plössl eyepiece, allowing it to be used successfully with lightweight telescopes and mounts. Included in the box is a 1.25-inch nosepiece extension, 1.5-metre USB 3.0 cable, ST4 guide cable and an installation CD.

Given that many laptops and PCs today don't include a CD or DVD drive, it's helpful that the software and drivers can also be found in the downloads section of Altair's website. Installing the camera drivers was simple, as Altair has bundled them into a single download. Altair's AltairCapture software can also be downloaded from this location if you aren't already running any astronomy capture software. Once installed, we plugged in the 678C, which was instantly recognised with no additional configuration required.

With a waxing Moon in the sky, we popped the Altair 678C onto our 8-inch Newtonian reflector. At 1,000mm focal length, the 2µm pixels gave a 0.41 arcseconds/pixel resolution, slightly short of the 0.25 arcseconds/pixel resolution commonly considered optimal for average seeing conditions. However, by adding our own 2x Barlow lens we increased the resolution to 0.21 arcseconds/pixel. Once attached, the Barlow and 1.25-inch extension gave us enough back focus to bring the Moon to a crisp appearance.

Steady speeds

The first thing we noticed was a green tint to the live view, confirmed by our software histogram. Checking the settings in AltairCapture, we were able to control the white balance and correct this. However, using different software (FireCapture) at a later session, we unfortunately didn't have the individual colour channel control allowed by some other cameras, so weren't able to balance the colour channels mid-operation. However, this could be easily corrected in post-processing, so wasn't detrimental to our images. ▶

High resolution, low amp glow

This latest GPCAM from Altair Astro features the new IMX678 Starvis 2 CMOS sensor from Sony. This 8.3MP colour sensor features 2µm pixels in a 3,840 x 2,160 array and promises capture speeds of up to 47fps at full resolution in 8-bit mode and more than 71fps when cropped to 1,920 x 1,080 resolution.

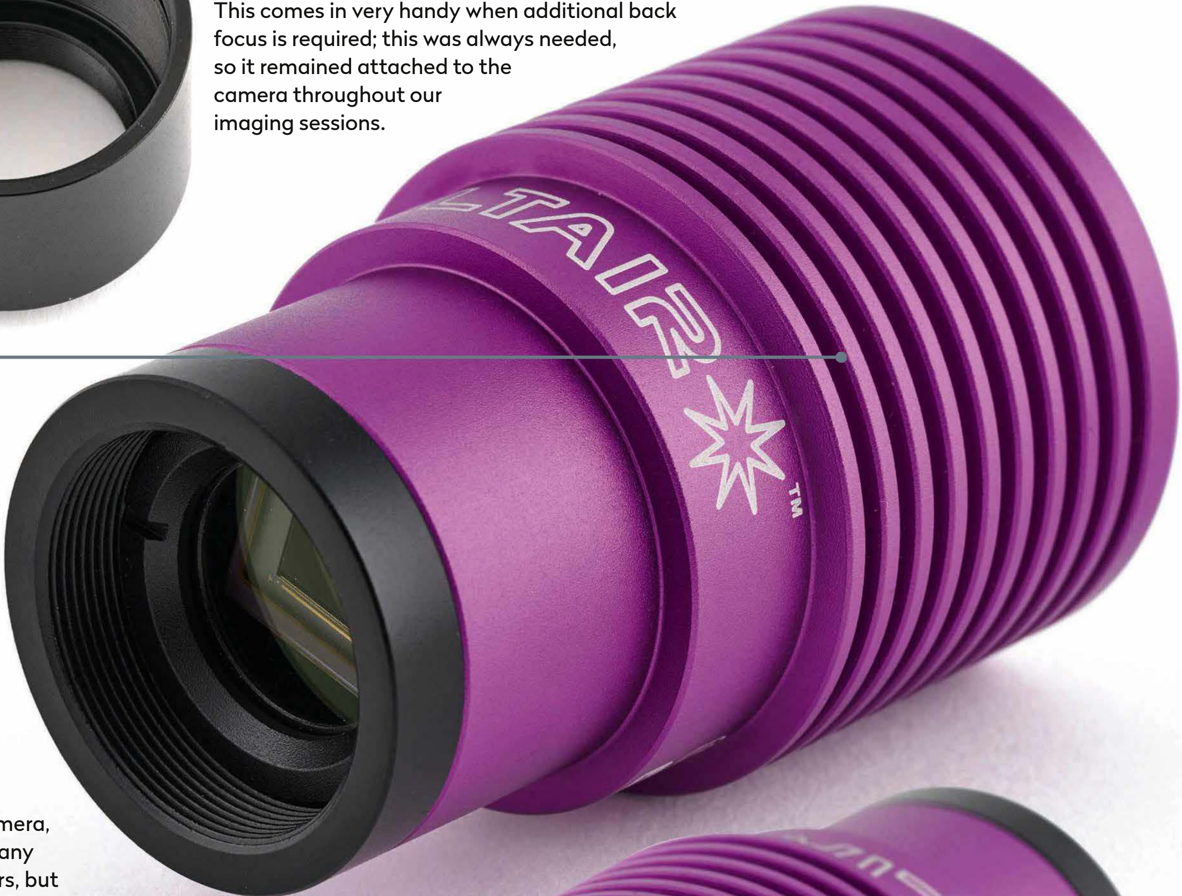
As this is a high-resolution sensor, it returns large file sizes: a two-minute capture at full resolution resulted in a 30GB file size, so hard drive space may be an issue. In fact, on a later session, we managed to fill our 500GB hard drive within a couple of hours.

Another area where the IMX678 excels is its ability to handle amp glow. With the cap still on our telescope, we tested this by running a series of dark calibration frames and pushing the exposure length up. Given that this camera is only passively cooled, we were still getting perfect amp-glow-free images at five-minute exposures.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

1.25-inch nosepiece

Despite the camera itself being 1.25 inches wide and therefore compatible with most focusers, Altair has also included a 1.25-inch nosepiece extension. This comes in very handy when additional back focus is required; this was always needed, so it remained attached to the camera throughout our imaging sessions.

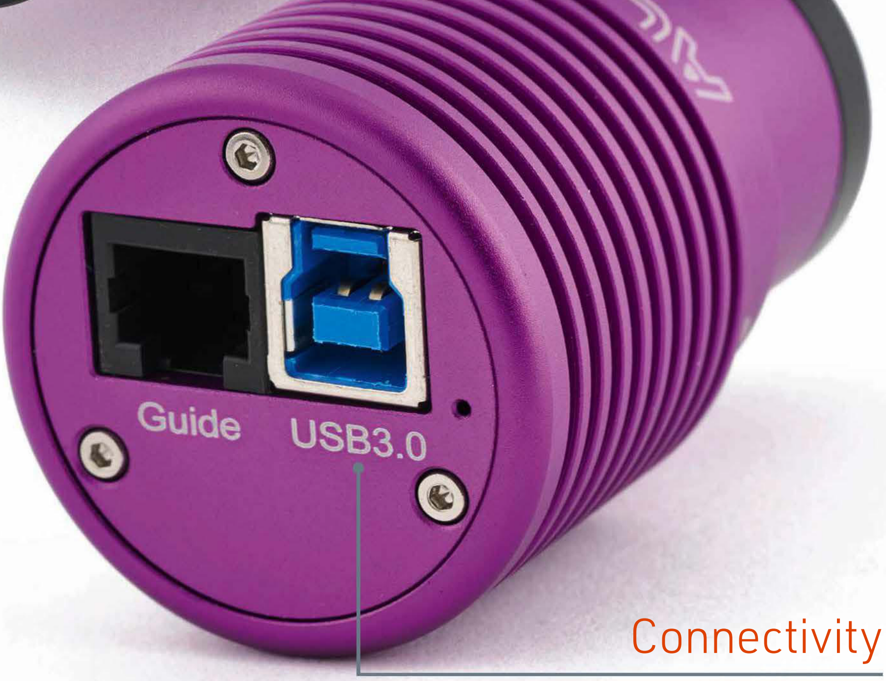


Passive cooling

The Altair 678C is a passively cooled camera, so does not include any fans or Peltier coolers, but instead uses heat sinks to disperse generated heat. To help disperse the heat, the body of the camera is ridged, increasing the surface area and allowing for quicker cooling mid-operation.

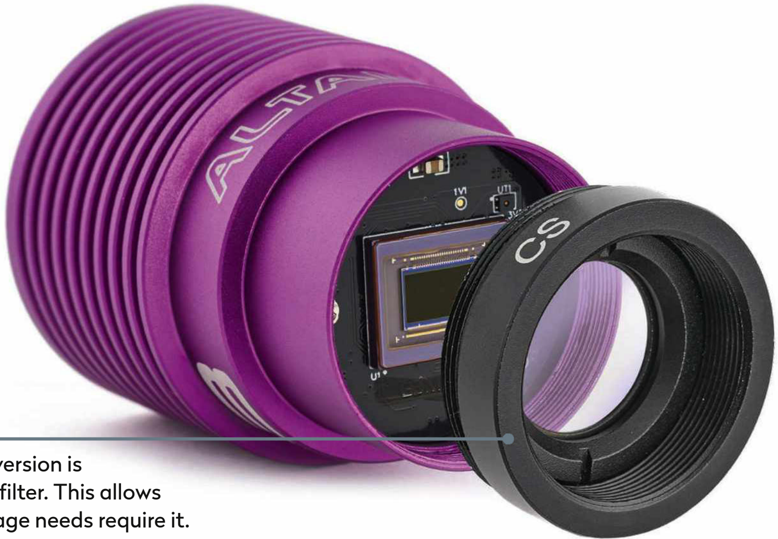
1.25-inch filter thread

The inside of the black removable filter is threaded for 1.25-inch filters, allowing the use of aftermarket IR/UV cut filters or other specialist filters like a quad-band for deep-sky use. Planetary imaging filters like IR pass or coloured filters can also be used when paired with a clear optical window.



Connectivity

Located on the back of the camera is a USB 3.0 port which, when combined with the supplied 1.5-metre cable, allows full PC control. Alongside this is a guide port that allows the Altair 678C to be connected to a mount and used instead as a guide camera.



Removable UV/IR filter

Secured within the nosepiece of the 678C version is a removable infrared and ultraviolet block filter. This allows us to change to a clear filter should our image needs require it. This also allows us to clean the sensor as and when needed.

KIT TO ADD

1. Altair Sentinus all-sky camera dome housing

2. Altair all-sky camera lens 180° FOV for CMOS camera

3. Altair 2-inch M48/M48 magnetic filter holder

▶ With the camera set to 8-bit mode and with the resolution set to maximum, we were easily able to achieve the advertised 47 frames per second (fps) with a balance of the exposure time/gain settings (gain 182, exposure 13.44ms). During a two-minute capture, zero frames were dropped and the capture speed was maintained throughout.

Finished with the Moon, we slewed over to Jupiter. With the planet in the centre of the field, we applied a tighter 'Region of Interest' setting focused on an area 350 x 350 pixels in size. This area was filled by Jupiter, with just enough black space around the edge to ensure we weren't clipping the planet. With the gain set to 245 and exposure time at 9.85ms, we were achieving an impressive 148fps on this smaller image.

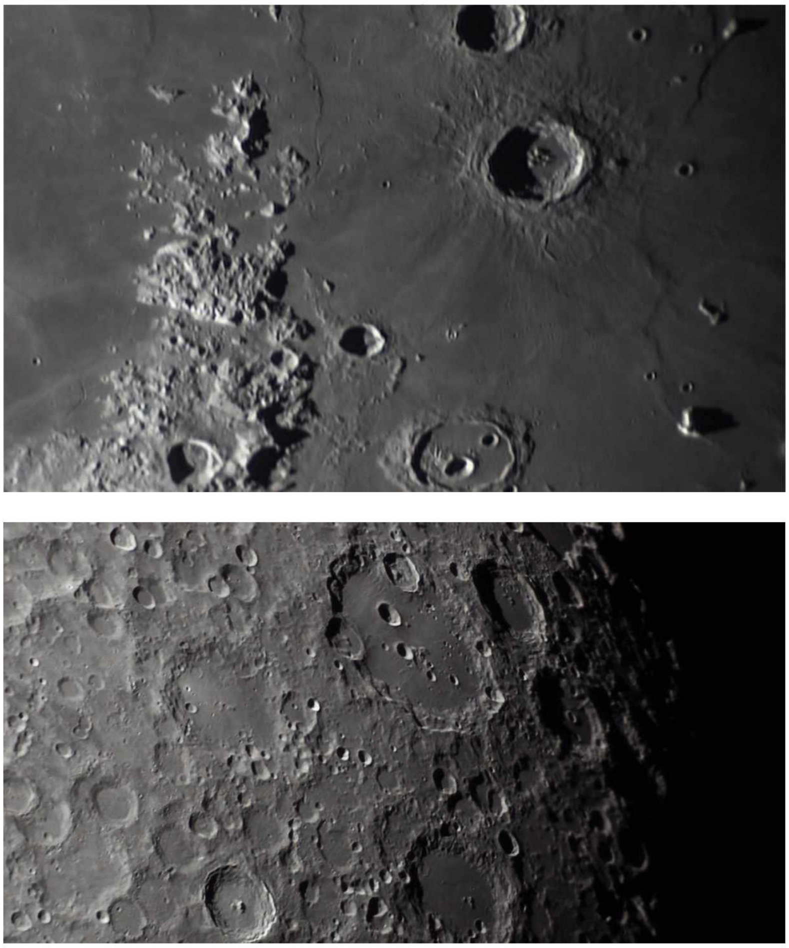
Hefty file sizes

Once we were happy with our captured videos, we proceeded to process our files. We started with AutoStakkert! but immediately hit an issue with the longer captures, in that our PC ran out of memory. This was overcome by adding an initial step of using PIPP (Planetary Imaging PreProcessor) to review the video, reorder it by quality and discard the worst frames. This reduced the file size sufficiently for AutoStakkert! to successfully process and stack the resulting video into a single image, ready for final processing and wavelets application in RegiStax.

It quickly became apparent that the new Altair GPCAM 678C is a very capable and user-friendly camera. Simple enough for beginners, it also returns images that will satisfy intermediate planetary imagers. From its straightforward setup to delivering consistently high frame rates at low gain settings, it was a pleasure to use and returned some excellent planetary images.

VERDICT

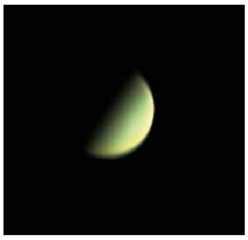
Build & design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★★☆
OVERALL	★★★★☆



▲ The Altair 678C's fast frame rate meant we could capture exceptionally sharp crater details in our Moon photos. Images were low on noise, so we were able to draw out further contrast and colour in post-processing

▲ Saturn: we kept gain settings low (198) and still achieved fast frame rates, increasing the number of good-quality stackable frames

▲ Jupiter: picking a tighter Region of Interest, we got great cloud detail in 120 seconds, 12.75ms shutter speed, 245 gain



▲ Venus: the 678C proved very capable at imaging the yellow half-disc. This was 180 seconds at 1.450ms, with the gain set to 100

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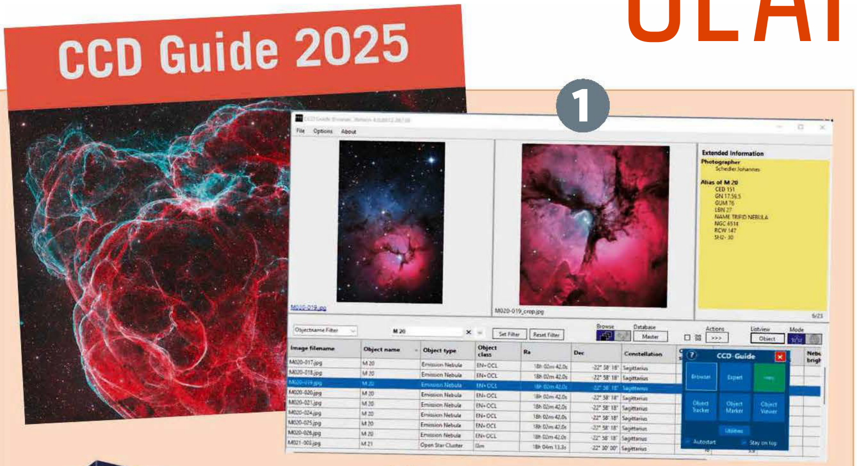
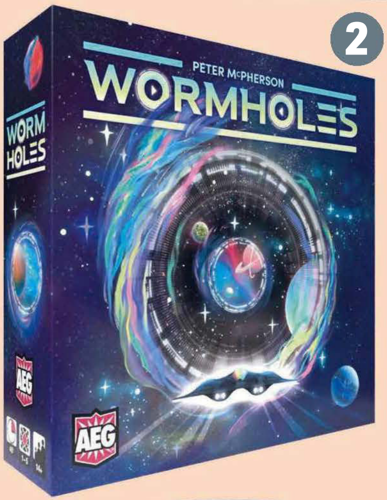
Charlotte Daniels rounds up the latest astronomical accessories

GEAR





Vixen SLV 5mm Field 50°
5
4

SATURN
planet no.6
5

1 CCD Guide 2025

Price from €29 • **Supplier** CCD Guide
www.ccdguide.com

This collection offers a database of over 5,000 astrophotos to plan and optimise imaging sessions according to your field of view and location, finding ideal observation windows for your target list. Updated for 2025 with even more images, the guide is available as either a download or on a USB stick.

2 Wormholes board game

Price from £35.99 • **Supplier** Athena Games
www.athenagames.com

Who doesn't love an astronomy-themed board game on a rainy day? Your goal is to build a network of wormholes and become the most successful captain among your teammates as you deliver passengers across the galaxy. For 1–5 players, ages 10 and over.

3 MeMstar telescope star pointing aid

Price £189 • **Supplier** First Light Optics
www.firstlightoptics.com

Accompanied by a smartphone app, this compact device attaches to the bottom of your telescope tube to convert any Dobsonian or altazimuth setup into a 'push-to' system. With a catalogue of almost 15,000 objects, this pointing aid could be your key to touring the cosmos.

4 Vixen SLV 50° 5mm eyepiece

Price £133 • **Supplier** Bresser
www.bresseruk.com

Vixen's 1.25-inch-barrel SLV eyepiece range features high-quality lanthanum glass and multi-coated lenses, ensuring clear and high-contrast images across the 50° field of view. The generous 20mm of eye relief and twist-up eyecups make this a promising option for spectacle wearers.

5 Saturn T-shirt

Price from £30 • **Supplier** BBC Earth
www.bbcearthteemill.com

This oversized T-shirt is sustainably produced from organic cotton and free from animal-derived products. Under the image of Saturn are some facts about our 'planet no. 6', including its diameter, number of moons and orbit. Available in sizes XS to 2XL.

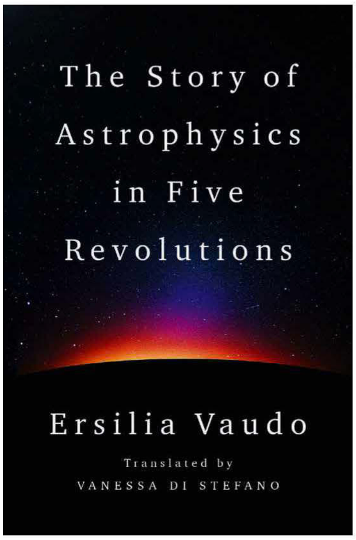
6 Space rug

Price £30 • **Supplier** IKEA
www.ikea.com

This Solar-System-themed rug looks perfect for any children's room or play den. It has a rubber backing to reduce movement or slippage, while the stain-resistant fibres should help ensure it survives any spills.

New astronomy and space titles reviewed

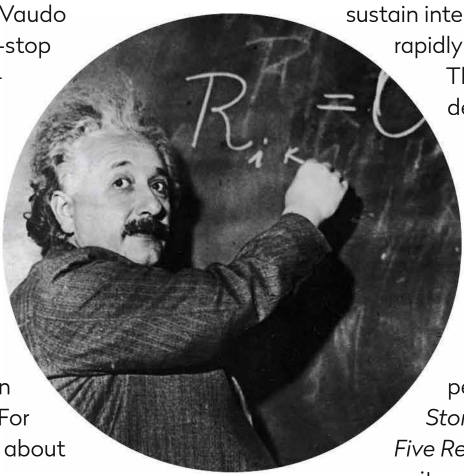
BOOKS



The Story of Astrophysics in Five Revolutions

Ersilia Vaudo
WW Norton
£17.99 ● HB

Astrophysicist Ersilia Vaudo takes us on a whistle-stop tour of modern (post-medieval) astronomy and astrophysics. Despite the title, this is not a book about five single revolutions in thinking, but five junctures in physics fuelled by many different revolutions in scientific endeavour. For example, the chapter about the Renaissance surveys the contributions of Galileo and Kepler to the Copernican worldview, but also the emergence of Newtonian physics and its successes. Another of the book's chapters concerns the relativistic and quantum physical innovations both kickstarted by Einstein. These are many revolutions amounting to radical changes in perspective. Other chapters cover the themes of general relativity, the expanding Universe and particle physics (specifically antimatter). The reader should expect to follow many threads that weave the author's five themes.



Einstein is among the revolutionary thinkers featured in Vaudo's history

KEYSTONE-FRANCE/GETTY

A welcome final chapter speculates on what the next revolution in astrophysics may be. Unsurprisingly, the two main topics are dark matter and dark energy. These, as well as the cosmic implications of advances in particle physics and unified theories, surely represent the next big hurdles in our quest for understanding, and the author ably whets the reader's appetite for the coming revelations.

Vaudo's writing is fluid and direct throughout (although lacking a little in analogy) and manages to convey basic concepts without unnecessary digression or complexity. However, this reader felt something may be lost in the translation from the original Italian, as some phrases don't seem to convey the urgency required, while others seem overstated. Thankfully, this doesn't distract from the story too negatively and there is much to sustain interest as the text rapidly advances.

There are much more detailed books that delve into the history of revolutionary ideas in astrophysics and the current status of dark matter/energy research. However, this is perhaps where *The Story of Astrophysics in Five Revolutions* surpasses its competitors: it is a very short book that can be read in only a few hours, but covers huge amounts of ground succinctly and adeptly. It is the perfect offering for a lazy afternoon diversion. ★★★★☆

***Alastair Gunn** is an astronomer at the Jodrell Bank Centre for Astrophysics*

Interview with the author

Ersilia Vaudo

When did what we now call astrophysics begin?

Newton's insight that the same physical laws governing objects on Earth also rule the motion of planets and stars opened new ways of understanding the cosmos. The birth of what we now call astrophysics came in the mid-19th century, when scientists began wielding powerful new tools to unlock the secrets of distant stars. Through spectroscopy, suddenly we could analyse the chemical makeup of celestial bodies. This transformed astronomy from a science of observation to probing the very nature of cosmic objects.

Is the rate of discovery getting faster?

Technological leaps in telescopes, detectors and computing let us see further and clearer than ever. A new era of multi-messenger astronomy means we can observe cosmic events through different signals: light, gravitational waves, neutrinos, cosmic rays. Global collaboration multiplies our collective power to understand the cosmos. Better tools, new detection methods and worldwide teamwork have ushered in a golden age of discovery.

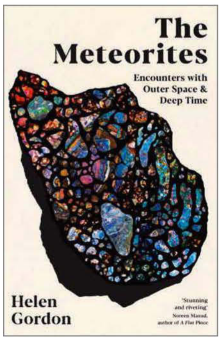
What could be the next revolution?

Cracking dark matter and dark energy would revolutionise physics. A theory of quantum gravity would unlock the secrets of black holes and the Big Bang. The matter–antimatter puzzle could explain why we exist at all. Finding extraterrestrial life would transform our cosmic perspective. Solving the dark energy mystery would likely have the most profound impact. It could force us to totally rethink the nature of space itself.

***Ersilia Vaudo** is an astrophysicist and chief diversity officer at the European Space Agency*

The Meteorites

Helen Gordon
Profile Books
£20 ● HB



This is a beautifully written and very human history of objects far older than human comprehension. Part travelogue, part history, part science, it features a cast of characters united by their love of meteorites, from big-time dealers and Indiana Jones-type collectors, to geologists, curators, cosmo-chemists and experimental archaeologists. Then there are the meteorites themselves, which Gordon describes in such careful detail they seem to be historical characters; she even talks about the impulse to wave to one upon their meeting.

We hear of the ways they are hunted, found upon the sands of the Sahara desert or standing out against the ice of the Antarctic, and how Egyptians obtained iron from meteorites some 2,000 years before it was first smelted by humans. We also learn of the risk of 'human' meteorites, satellites falling out of low Earth orbit, as well as the unlikely but real risk of a catastrophically dangerous impact.

While this isn't a typical science book – astrogeology-obsessed readers may want to look elsewhere for hard facts – *The Meteorites* is a moving portrait of the ways astronomy touches our lives. Meteorites aren't just distant objects but deeply intertwined with human history. Several of those interviewed say they became fascinated with meteorites because although they themselves were unlikely to go into space, pieces of space could come to them, as something they can touch and even own.

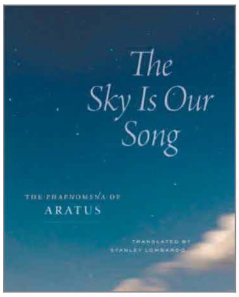
By turns informative, funny and touching, this is a book not just about meteorites, but about art, history and humanity itself. ★★★★★

***Katie Sawers** is a science writer and associate editor at IOP Publishing*

The Sky is Our Song

ASTRO CLASSICS

Aratus, translated by Stanley Lombardo
University of Chicago Press
£20 ● HB



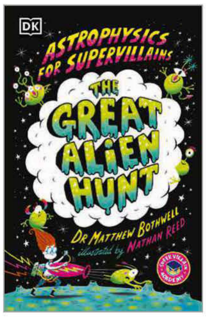
Written in 270 BC by Aratus, an ancient Greek didactic poet, this famous poem *Phaenomena* was extremely popular throughout the ancient world – and it's easy to understand why. For this modern edition, which uses the first line of the poem for its title, Stanley Lombardo, an American classicist and amateur astronomer, has beautifully translated *Phaenomena* into vernacular English, making this poetic guide to the heavens accessible to all.

His introduction sets the scene, helping us understand what is to come and how the poem is structured. The poem describes the constellations in both hemispheres, the planets, the lunar cycle and weather. From a miniature dolphin floating in the mist or the Milky Way described as a band of jewels in the sky, the words are romantic and emotional. Each page is accompanied by simple illustrations of the constellations being explored, while the endnotes are well-needed and informative, explaining individual lines where a little more elucidation is required.

Written in such a simple but descriptive way, *The Sky is Our Song* is a delightful and less conventional way of learning about the night sky, evoking feelings of a deep connection with the heavens above, stirring our imagination and a longing to sit under the stars. Don't be fooled by this small hardback; this is an astronomy book that will have an unexpected effect on you and one that will undoubtedly be read repeatedly. It really is something extraordinary. ★★★★★

***Katrin Raynor** is an astronomy writer and speaker*

Astrophysics for Supervillains 2: The Great Alien Hunt



Matthew Bothwell
DK Children
£7.99 ● PB

The second entry in the Astrophysics for Supervillains series, like its predecessor is a fun exploration of exoplanets and alien life. Written for upper-primary or middle-school students, *The Great Alien Hunt* is essentially a stand-alone that doesn't rely on the previous book in the series.

The book certainly doesn't shy away from complex topics, but they're explained in a very accessible way. From the search for planets in our Solar System to atmospheric spectroscopy, to Dyson spheres and even time dilation, there's a lot of information to absorb.

As before, there's not too much about supervillainy, but it's a good excuse to explore the cosmos. After learning how planets in our Solar System were discovered and which ones might be inhabitable, we move outwards to find exoplanets and ask what we mean by alien life. There's a fun exploration of how long it would take to travel to alien worlds, including the weird effects of travelling very fast, and we end on philosophical questions such as the famous Fermi paradox: where is everybody?

In a style familiar to children of this age, text is written in spoken voice, so one can imagine shouting the large, bold all-caps and whispering the lighter text.

In terms of what a younger reader thinks, Felicity (age 9) described it as "grabbing your attention immediately, very educational and extremely funny (especially the joke about year 7 teachers)". I heard lots of audible laughs at the "little jokes" (such as planets called George and spacecraft called Bob) from my co-reviewer. Like me, she highly recommends it. ★★★★★

***Chris North** is head of public engagement in the School of Physics and Astronomy at Cardiff University*

Ezzy Pearson talks to Dr Nelli Mosavi-Hoyer

Q&A WITH AN AURORA SCIENTIST

Powerful electrical currents guide the Northern and Southern Lights. For the first time, a trio of satellites called EZIE is studying how these 'electrojets' work

What is the EZIE mission?
EZIE stands for Electrojet Zeeman Imaging Explorer. For the first time, we will image and map electrical currents inside the aurora, called electrojets. These are high-intensity currents that flow 100km (60 miles) above Earth's upper atmosphere, in the ionosphere, near the North and South Poles. They push about a million amps of electric current around the poles every second.

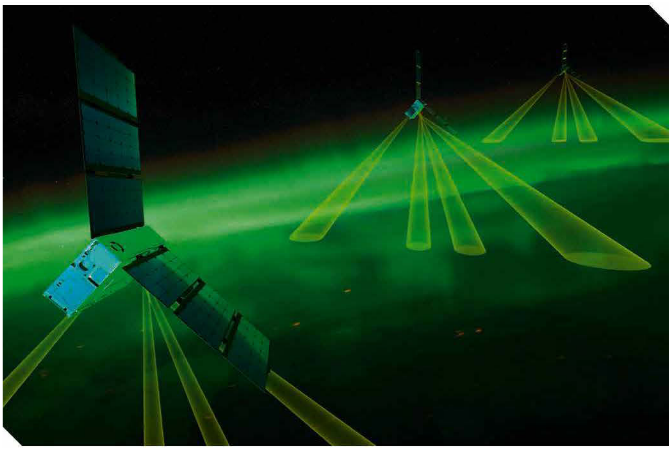
What creates these electrojets?
They're formed by interactions between the Sun's energy, and Earth's magnetic field and upper atmosphere. The Sun constantly sends out charged particles in a stream called the solar wind. When these reach our planet, our magnetic field guides them towards the Poles where they enter the ionosphere. As these particles move through the ionosphere, they create powerful electric currents. Electrojets and aurorae are closely connected. When these solar wind particles hit Earth's atmosphere, they also create the beautiful Northern and Southern Lights by exciting gases in the sky.

We are sending the EZIE satellites at the peak of the solar cycle, the approximately 11-year pattern of rising and falling activity on the Sun. Electrojets are more active during the peak of the solar cycle, which means more opportunities to study their behaviour.

How will EZIE image those currents?
We're using a very new technique, called the Zeeman effect, to study the magnetic field. There's a very well-known phenomenon where oxygen molecules create microwave emissions at 118GHz. If there is a magnetic field close to these oxygen molecules, it will split that emission into multiple wavelengths. By studying the amount of splitting, we can calculate the strength and direction of the magnetic field that is affecting the oxygen molecules. If you have information about the magnetic field, you can work backwards and find the current responsible for it.

What does the mission look like?
We have three CubeSats the size of a suitcase, moving 2–10 minutes apart from each other. These are following each other in polar orbit at an altitude of approximately 550km (350 miles). The unique thing about this spacecraft is we don't have propulsion. We glide them. You can think of the solar panels as a glider's wing; we command the solar panels to move and that helps us control the separation between the spacecraft.

We need at least two spacecraft to understand how the electrojets evolve over time. We want to know in the 2–10 minutes [between them] how much the size, shape and flow patterns of those current have changed. By understanding the changes, we can tell which direction the current is going, its intensity and its structural evolution. Our goal is to operate for 18 months after launch, though we think by the first five or six months we will answer all our key questions.



▲ NASA launched its three electrojet-mapping satellites into Earth's upper atmosphere on 14 March

What are you trying to find out?
We'd like to understand the structure and evolution of the auroral electrojets, and their impact on space weather. This is the first mission to look at the aurora in this depth. Electrojets flow in a region that is hard to study because it's too high for balloons and too low for satellites to operate. EZIE is the perfect distance, and the sensors are exactly focused on what we're interested in. Up to this time, we didn't have the technology to do this.

What impact do the currents have here on Earth?
Electrojets are part of a huge electric circuit that connects Earth to space. These electrojet currents can cause sudden changes in Earth's magnetic field. That can create large magnetic disturbances on the ground if there's an interruption in the current, sometimes leading to power grid disruptions and satellite issues.

Auroral electrojets are one of the key elements that we don't have information about when it comes to predicting space weather, and by studying them in detail, scientists will be able to reduce its impact. Space weather can also harm astronauts, so understanding these currents will help the next generation wanting to go into space.

Nelli Mosavi-Hoyer is the programme manager of the EZIE mission at Johns Hopkins University Applied Physics Lab

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WAVE-100i MOUNT HEAD
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Wi-Fi SYNSCAN GO-TO

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Wi-Fi SYNSCAN GO-TO

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Fusion-120i in Equatorial Mode

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DOUBLE STACK PERFORMANCE FROM A SINGLE ETALON!
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Front Etalon: Diameter 40mm, Bandwidth <0.6 Angstrom, Tuning Method: Pressure Tuning, 8mm Blocking Filter, ISO 12312-2:2015 Compliant

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BBC SKY AT NIGHT MAGAZINE

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Objective Lens: 80/400, Filter Wheel with Colour Filters, Smartphone Adaptor, ISO 12312-2:2015 Compliant

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Hello Find

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Payload Capacity 4kg
Compatible with Heliostar-76a, Acuter Elite Phoenix 40 & Solarus-80 OTAs
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"The SolarQuest is elegant in its simplicity and works like a dream"
BBC SKY AT NIGHT MAGAZINE

Sky at Night MAGAZINE ★★★★★
REVIEWED IN Issue 159 August 2018

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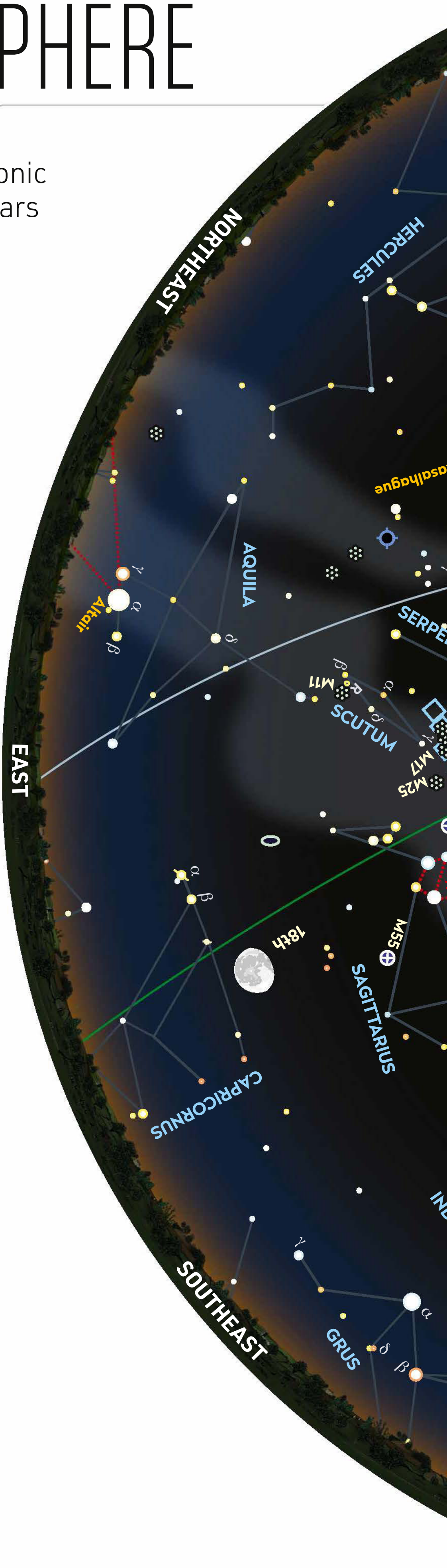
THE SOUTHERN HEMISPHERE

With Glenn Dawes

Crux may be the tiniest constellation, but this iconic region holds a jewel box of brilliant, colourful stars



When to use this chart

1 May 00:00 AEST (30 Apr, 14:00 UT)
15 May 23:00 AEST (13:00 UT)
31 May 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

MAY HIGHLIGHTS

The Eta Aquariid meteors are linked to Halley's Comet and are swift, distinctly yellow and known for leaving persistent trains. In 2025, they're expected to be visible from 19 April to 28 May, peaking on the morning of 6 May, when the Moon is eight days old and skies will be Moon-free. The shower is popular with Southern Hemisphere observers, with its radiant from mid-latitude Australia reaching 40° altitude in the northeast just as dawn breaks in early May.

STARS AND CONSTELLATIONS

Evening skies are dominated by Crux, aka the Southern Cross. It's so iconic to the Southern Hemisphere it features on the flags of five nations: Australia, New Zealand, Papua New Guinea, Samoa and Brazil. Crux is the smallest constellation, with its boundaries just a few degrees outside of its four brightest stars. Don't let its stature fool you; it's embedded in a rich part of the Milky Way and endowed with brilliant star fields – an impressive sight even through binoculars under dark skies.

THE PLANETS

As twilight descends, Jupiter is low in the northwest and soon lost from the evening sky. Mars is crossing the meridian around sunset, departing late evening. As May opens, there's a morning flurry of activity, with Saturn, Neptune and Venus rising together around 03:00. As the month progresses, Saturn and Neptune rise earlier, slowly separating from brilliant Venus. May commences with Mercury briefly visible in the dawn sky but is lost to the Sun's glare towards month's end.

DEEP-SKY OBJECTS

This month, a trip to Crux. Starting at the bottom (southernmost) brightest star, first-magnitude Alpha (α) Crucis, move 1.3° north to discover the mag. +7.4 open cluster NGC 4349 (RA 12h 24.1m, dec. –61° 52'). This compact cluster, 12 arcminutes across, consists of around 100 11th-magnitude stars, its members appearing arranged in curved lines interspersed with voids, surrounded by an impressive Milky Way field.

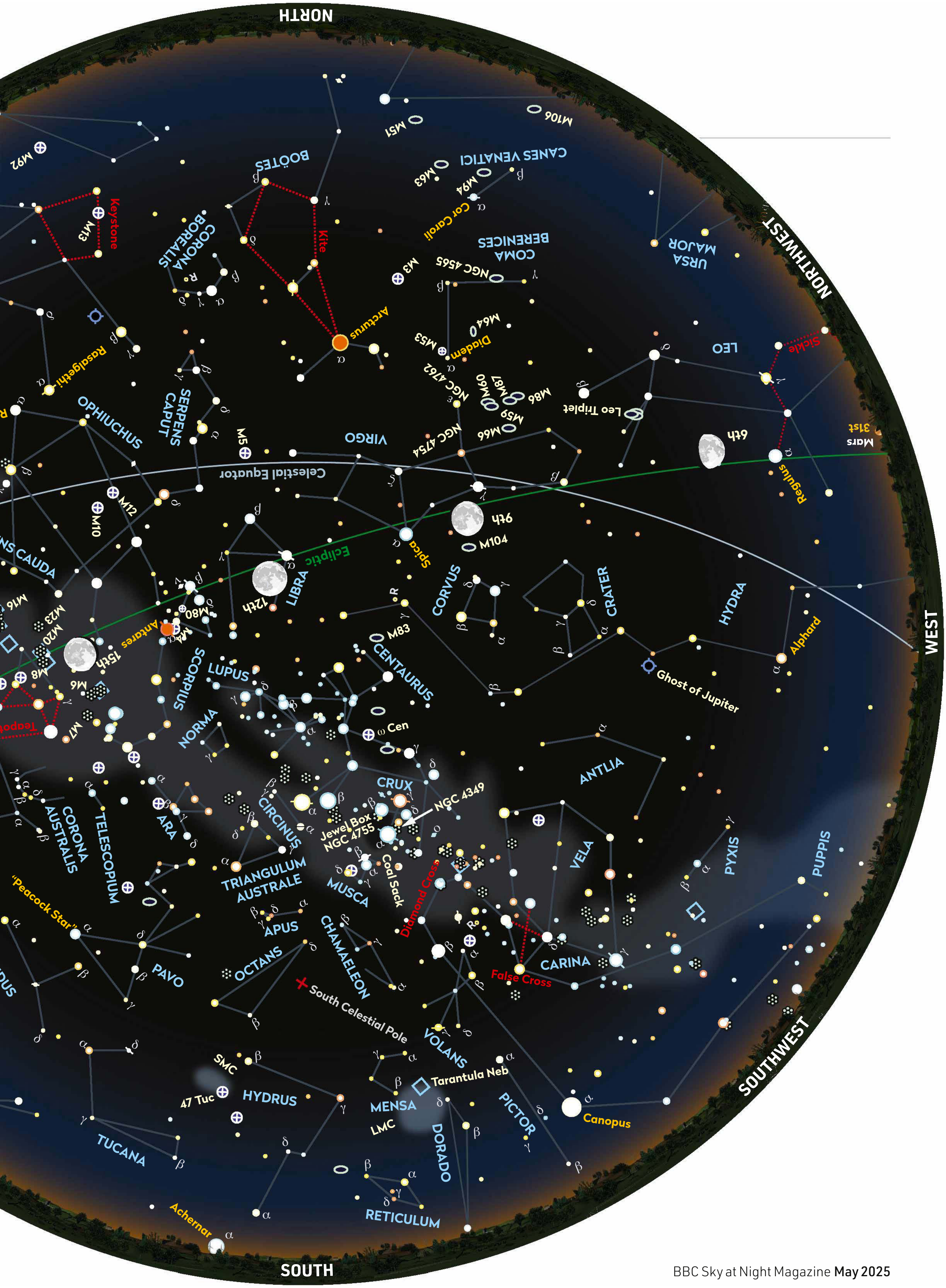
Here's Crux's showstopper, another compact open cluster, NGC 4755. Called the Jewel Box (RA 12h 53.6m, dec. –60° 20') and visible in the same binocular field as Beta (β) Crucis, this 10-arcminute-diameter group is best known for its brightest (eighth-magnitude) half-dozen blue/white stars in a distinctive 'A' shape. It's capped off by an obvious red central star, making the cluster look like a ruby in a diamond setting – hence its nickname.

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
M92
M13
Keystone
BOÖTES
Kite
CORONA BOREALIS
R
M51
M106
CANES VENATICI
M63
M94
Cor Caroli
COMA BERENICES
URSA MAJOR
M3
NGC 4565
Arcturus
M64
M53
Diadem
NGC 4762
M60
M87
M86
M59
Leo Triplet
LEO
Sickle
Rasalgethi
OPHIUCHUS
SERPENS CAPUT
M5
VIRGO
NGC 4754
M66
6th
Mars
31st
Regulus
Celestial Equator
M12
M10
9th
M104
Spica
Ecliptic
LIBRA
12th
SERPENS CAUDA
M16
M23
M20
M80
M4
Antares
15th
M8
M6
M7
Teapot
CORVUS
CRATER
HYDRA
Alphard
M83
CENTAURUS
Ghost of Jupiter
SCORPIUS
LUPUS
NORMA
ω Cen
ANTLIA
CRUX
NGC 4349
Jewel Box NGC 4755
CIRCINUS
ARA
CORONA AUSTRALIS
TELESCOPIUM
TRIANGULUM AUSTRALE
MUSCA
Coal Sack
Diamond Cross
VELA
PYXIS
PUPPIS
"Peacock Star"
APUS
CHAMAELEON
CARINA
False Cross
PAVO
OCTANS
South Celestial Pole
VOLANS
SMC
47 Tuc
HYDRUS
Tarantula Neb
MENSA
LMC
PICTOR
Canopus
TUCANA
DORADO
RETICULUM
Achernar